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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

17-AMRP-0082

JAN 17 2017

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EDMC

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State Department of Ecology
3100 Port of Benton Boulevard
Richland, Washington 99354

Dear Ms. Smith:

CLASS 2 MODIFICATION REQUEST TO REVISE GROUNDWATER MONITORING PLANS FOR THE 183-H SOLAR EVAPORATION BASINS AND 300 AREA PROCESS TRENCHES

In accordance with the Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste (Permit) Condition I.C.3, this letter hereby transmits a Class 2 permit modification request. The attachments identify proposed changes to the groundwater monitoring plans for the 183-H Solar Evaporation Basins and the 300 Area Process Trenches post-closure units. The proposed changes address the constituents to be monitored, sampling frequency, concentration limits, statistical evaluation processes, and the compliance period.

Attachment 1 addresses changes to 300 Area Process Trenches groundwater monitoring requirements. Attachment 2 addresses changes to the 183-H Solar Evaporation Basins groundwater monitoring requirements. Attachment 3 contains a certification statement signed by the U.S. Department of Energy as the Facility Owner/Operator.

The notices required by Washington Administrative Code 173-303-830(4)(b)(ii) will be included in the appropriate Hanford Federal Facility Agreement and Consent Order publication or list server, pursuant to Permit condition I.C.3.

The U.S. Department of Energy Richland Operations Office and the Washington State Department of Ecology use identification numbers to help track permit modifications. This modification package addresses the following identification numbers:

Identification Number:	**Affected Permit Section**
C2-300APT-2016-01	PCU-1 (Conditions and Addendum D)
C2-183-H-2016-01	PCU-2 (Conditions and Addendum D)

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If you have any questions, please contact me, or your staff may contact Ray Corey, Assistant Manager for the River and Plateau on (509) 373-9971.

Sincerely,

Doug S. Shoop
Manager

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Attachments

cc w/attachs:
J. L. Cantu, Ecology (CD)
Administrative Record, TSD: D-3-1 and T-1-4 (Hard Copy & CD ROM)
Ecology NWP Library (Hardcopy & CD)
Environmental Portal (CD)
Gonzaga University, Foley Center Library (CD)
HF Operating Record (J. K. Perry, MSA, A3-01) (CD)
Portland State University, Government Information (CD)
U.S. Department of Energy, Public Reading Room, Washington State University, Tri Cities, Consolidated Information Center, (CD)
University of Washington, Suzzallo Library, Govt. Publications Department (CD)

cc w/o attachs: See page 3

cc w/o attachs:
D. J. Alexander, Ecology
A. S. Carlson, Ecology
L. J. Cusack, CHPRC
S. L. Dahl-Crumpler, Ecology
W. R. Faught, CHPRC
M. E. Jones, Ecology
P. W. Martin, CHPRC
J. S. Ni, CHPRC
F. A. Ruck, CHPRC
E. R. Skinnarland, Ecology
M. B. Wilson, MSA

ENCLOSURE 1

Changes to 300 Area Process Trenches Groundwater Monitoring Plan

Consisting of 300 pages,
including this cover page

Hanford Facility RCRA Permit Modification Notification Forms

Parts VI, 300 Area Process Trenches, Post Closure Unit Group 1 (PCU-1)

Index

Page 2 of 3 Chapter 3.0, Groundwater Monitoring Plan

Page 3 of 3 Revision Instructions

Hanford Facility RCRA Permit Modification Notification Form

Unit:	Permit Part
300 Area Process Trenches, Post Closure Unit Group 1 (PCU-1)	**Part VI (PCU-1), Chapter 3.0**

Description of Modification:

Chapter 3.0 (Groundwater Monitoring Plan) - The proposed changes to the Groundwater Monitoring Plan are substantial. Hence, a red-line/strike-out version of the changes is impractical. The Groundwater Monitoring Plan currently in the permit (WHC-SD-EN-AP-185) is being replaced, in its entirety, with a new plan (DOE/RL-2015-29, REV. 0). The new plan revises the constituents to be monitored, sampling frequency, concentration limits, statistical evaluation processes, and the compliance period.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:			X	

Enter relevant WAC 173-303-830, Appendix I Modification citation number: Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 2.

Revision Instructions:

Remove PCU-1, Chapter 3.0 Groundwater Monitoring Plan (WHC-SD-EN-AP-185) and replace with the new plan provided herein (DOE/RL-2015-29, REV. 0).

1 **Chapter 3.0** **300 Area Process Trenches Groundwater Monitoring Plan**

2 3.0 300 AREA PROCESS TRENCHES GROUNDWATER MONITORING PLAN 3.i

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SUPPORTING DOCUMENT

1. Total Pages 159

2. Title	3. Number	4. Rev No.
Groundwater Monitoring Plan for the 300 Area Process Trenches	WHC-SD-EN-AP-185	0

5. Key Words

RCRA, Final Status, Compliance Monitoring

6. Author

Name: J. W. Lindberg
C. J. Chou
V. G. Johnson

Signature: 5-17-95
C.J. Chou 5-19-95
Organization/Charge Code DM623/R4CHA

7. Abstract

This document outlines the groundwater monitoring plan, under RCRA regulations in 40 CFR 264 Subpart F and WAC 173-300-645, for the 300 Area Process Trenches. The 300 Area Process Trenches will go into final status in September 1995 and sampled under a compliance monitoring program. This plan provides current program conditions and requirements.

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8. RELEASE STAMP

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	U.S. Department of Energy
DQO	data quality objectives
DWS	Drinking Water Standards
ECOLOGY	State of Washington Department of Ecology
Eh	redox potential
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
GeoDAT	Geosciences Data Analysis ToolKit
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
OU	operable unit
PCE	perchloroethylene
POC	point of compliance
PNL	Pacific Northwest Laboratory
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act of 1976
TCE	trichloroethylene
TSD	treatment, storage, and disposal
VOA	Volatile Organic Analysis
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

This document describes the groundwater monitoring program for the Hanford Site 300 Area Process Trenches (300 APT). The 300 APT are a *Resource Conservation and Recovery Act of 1976* (RCRA) regulated unit. The 300 APT are included in the *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*, Permit No. WA890008967, (referred to herein as the Permit) (Ecology 1994) and are subject to final-status requirements for groundwater monitoring (Ecology 1994).

This document describes a compliance monitoring program for groundwater in the uppermost aquifer system at the 300 APT. This plan describes the 300 APT monitoring network, constituent list, sampling schedule, statistical methods, and sampling and analysis protocols that will be employed for the 300 APT. This plan will be used to meet groundwater monitoring requirements from the time the 300 APT becomes part of the Permit and through the postclosure care period until certification of final closure.

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1.1 HISTORY OF GROUNDWATER MONITORING AT THE 300 APT

An extensive groundwater monitoring program was carried out during the operational life of the 300 APT (1975 to 1994). Prior to, and continuing beyond the time the 300 APT went into service, many of the wells in the 300 Area were monitored for both radioactive and nonradioactive constituents, as well as water levels. In 1994, Ecology issued a RCRA Permit for the Hanford Site (Ecology 1994). The effective date of the Permit was September 28, 1994. RCRA treatment, storage, and disposal (TSD) units included in the Permit are required to conduct a final status groundwater monitoring program (see Section 1.2). Only five TSD units were included in this Permit originally. The 300 APT is scheduled to be included in the Permit as a TSD unit undergoing closure through the permit modification process in September 1995. Currently, the *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) Record of Decision is not completed. Consequently, final closure specifications (e.g., cleanup levels, remediation methodology) are not yet known to the closure process. In 1977, Pacific Northwest Laboratory (PNL) initiated a site-specific program of groundwater monitoring. During the first year of the program, groundwater samples were collected monthly from approximately 30 wells, and water levels were measured weekly. A reduced level of effort was continued on this program until 1985.

From 1985 to the present the 300 ATP site has been regulated under RCRA. The first groundwater monitoring compliance plan was initiated in 1986 (Schalla et al. 1986). In the *Consent Agreement and Compliance Order* (Ecology and EPA 1986) the 300 ATP site was placed in an interim-status groundwater quality assessment monitoring program. The assessment-" level status was based on the decision that (1) the groundwater monitoring wells around the 300 APT were inadequate for alternate groundwater monitoring as described in 40 CFR 265.90(d) (EPA 1984) and Washington Administrative Code (WAC) 173-303-400 (Ecology 1986) and (2) the groundwater quality in the 300 Area had been adversely impacted by the operations of the 300 APT. In response to the *Consent Agreement and Compliance Order* over 20 additional

wells were installed and monitored. The 300 ATP site was extensively characterized (Schalla et al. 1988b), and a revised groundwater monitoring compliance plan (Schalla et al. 1988a) was implemented in 1988. The plan has been modified as groundwater data were collected and analyzed. The data are reported to the State of Washington Department of Ecology (Ecology) quarterly, along with data from other RCRA-regulated units at the Hanford Site. Interpretive reports are submitted to Ecology annually.

The 300 APT are located in the 300-FF-1 source operable unit (OU) and 300-FF-5 groundwater OU, under the authority of RCRA TSD and CERCLA past practice. In an expedited response action (ERA) in 1991, sediment from the sides and bottom of the trenches was removed and stored at the northern ends of the trenches. The action lowered the concentrations of uranium and various nonradioactive constituents, but uranium, trichloroethylene (TCE), and cis-1,2-dichloroethylene (cis-DCE) are still detected in downgradient wells. Any additional corrective action deemed necessary will be deferred until decisions are made regarding the 300-FF-1 and 300-FF-5 OUs.

1.2 CHANGES FROM INTERIM-STATUS GROUNDWATER MONITORING

Interim- and final-status groundwater regulations differ in several respects. The "assessment" program under interim status is equivalent to a "compliance" program in final status. In compliance monitoring, specific constituents are chosen and compared to concentration limits. If these limits are exceeded, the site enters a corrective action phase. Statistical methods proposed in this document are different than those used under interim status. Final-status regulations require independent samples, which involves waiting periods between samples, rather than filling multiple bottles at once (replicates). In final status, samples are required at least semiannually rather than quarterly as in interim status.

The proposed program has a smaller monitoring well network and a shorter constituent list than the previous program. A complete description of the proposed groundwater monitoring program is presented in Section 4.0.

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2.0 FACILITY DESCRIPTION AND OPERATION HISTORY

The 300 APT are located in the 300 Area of the Hanford Site (Figure 2-1). The 300 Area is a research and former nuclear fuels operations area encompassing approximately 2.9 km^2 (720 acres) in the southeastern portion of the Hanford Site. Figure 2-2 shows the 300 Area main facilities.

The 300 APT began operating in 1975 and was the main facility for disposal of most liquid process wastes generated in the 300 Area until the trenches were removed from service. The liquid waste discharged to the 300 APT consisted mostly of wastewater with relatively low concentrations of chemical contaminants. More concentrated wastes were generally not discharged to the 300 APT. The discharge rate has varied over the years, but it reached a maximum average of about 8,641 L/min (2,283 gal/min) during 1979. Total discharge for 1979 was 4.5E9 L (1.2E9 gal). Since 1987, when fuels fabrication ceased in the 300 Area, the wastewater has consisted of cooling water with small quantities of nonhazardous maintenance and process waste. When the 300 APT were in use, the east and west trenches were used alternately for periods of up to approximately 8 months. The west trench was removed from service in November 1992; the east trench remained in service with an average discharge of 814 L/min (215 gal/min). The 300 APT was administratively isolated from receiving further discharges in December 1994 and was physically isolated in January 1995.

The 300 APT consist of two separate 457-m- (1,500-ft-) long trenches excavated 3.7 m (12 ft) into the subsurface and separated by an earthen berm. The unlined trenches are excavated into the sandy gravels of the Hanford formation, and the bottoms of the trenches are about 6.1 m (20 ft) above the water table. Figure 2-3 contains a schematic cross section showing the dimensions and relationship of the eastern trench to the water table and the nearby Columbia River. Figure 2-3 also shows the area in plan view with the location of the schematic cross section, some example well locations, and nearby facilities. If the cross section were continued to the west to include the western trench, it would look very similar to the eastern trench except for the enlarged northern end which is caused by a natural depression (Figure 2-4). In 1990, the depression was separated from the west trench by a berm needed to support a birdscreen placed over the trench. The north 91 m (300 ft) of the original trenches, including the depression, are now an impoundment area for covered, low-level radioactive and low-level, mixed waste soils.

A concrete weir box is located at the south end of the trenches. Process sewer effluent reached the trenches through 24-inch-diameter 300 Area Process Sewer System piping that is connected to the weir box. The weir box measures 21.3 m (70 ft) long (east-west dimension), 3 m (10 ft) high, and 3 m (10 ft) wide. It has two sluice gates that, in the past, allowed the trenches to be operated alternately.

Administrative controls to prevent disposal of dangerous wastes to the 300 APT were instituted on February 1, 1985. Prior to that time, a variety of chemical wastes was included with the wastewater. However, no large quantity of any one waste was included in the process wastes. Estimated amounts of chemicals discharged to the 300 APT are summarized in Table 2-1. From the

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Figure 2-1. Location of the 300 Area and the Hanford Site.

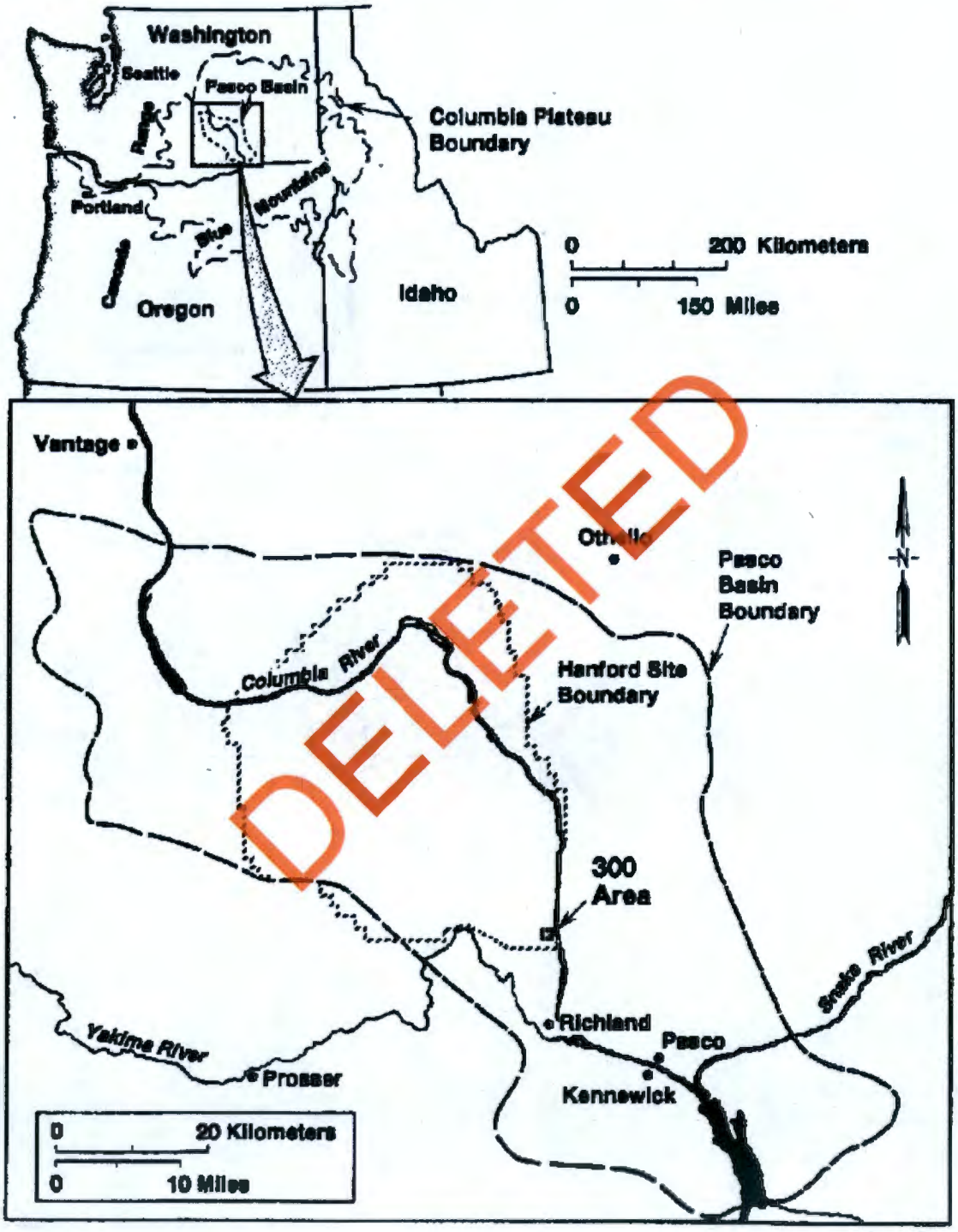

Figure 2-2. Locations of Main Facilities in the 300 Area.

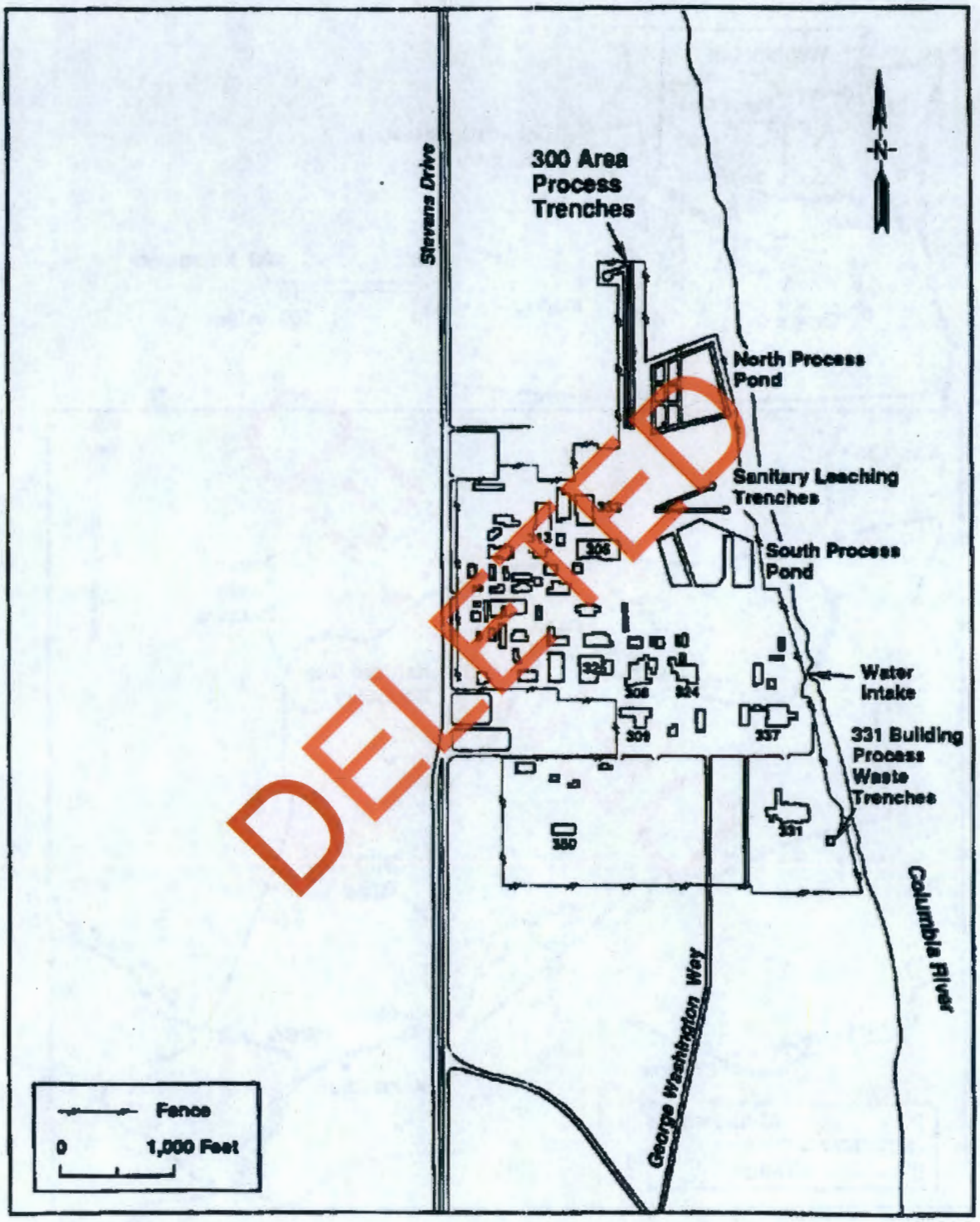

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Figure 2-3. Schematic Cross Section of the 300 Area Process Trenches (modified from Schalla et al. 1988b).

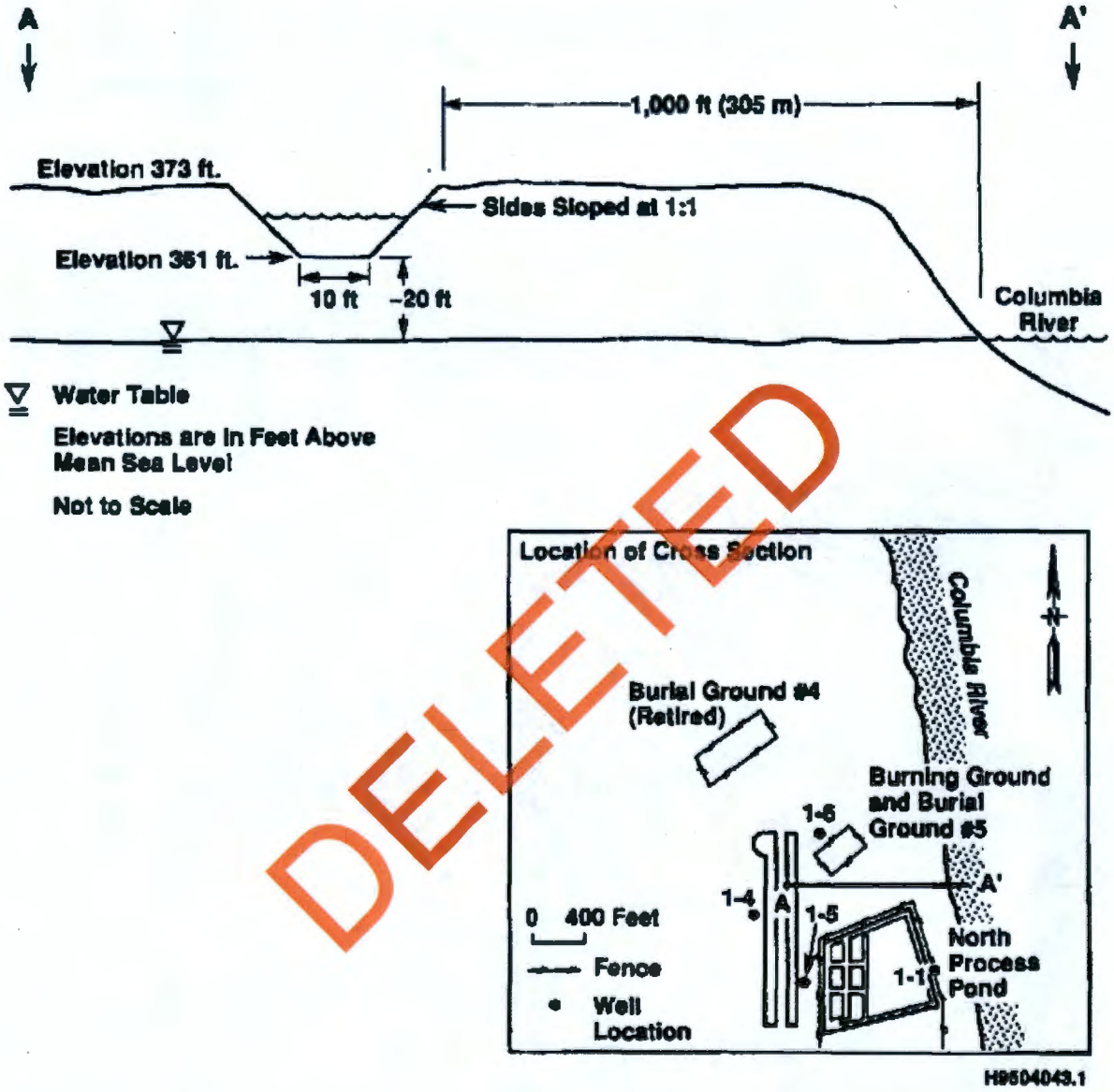

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Figure 2-4. Topography in the Vicinity of the 300 Area Process Trenches.

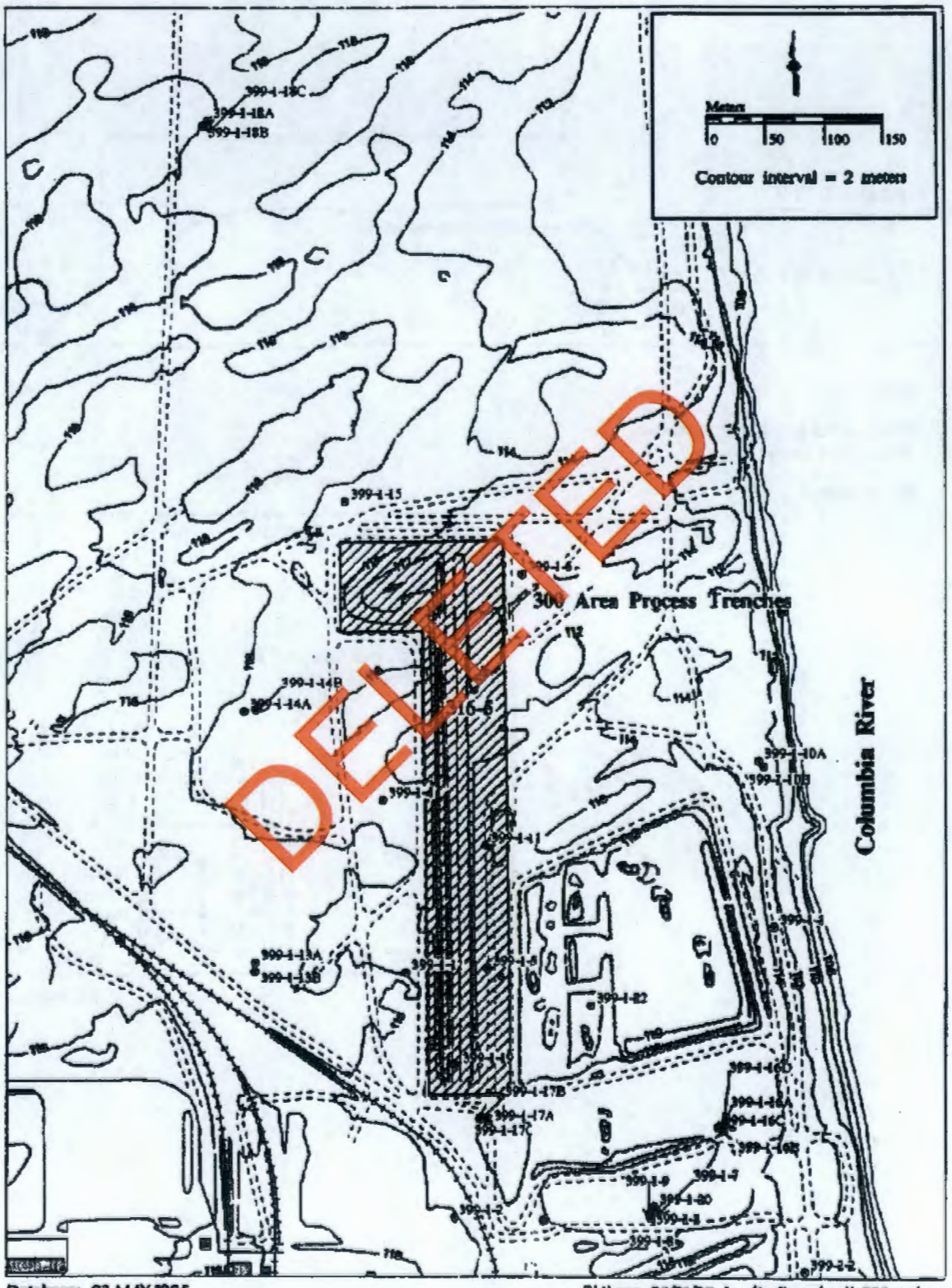

Table 2-1. An Estimate of Chemicals Discharged to the 300 Area Process Trenches Prior to February 1, 1985 (modified from Schalla et al. 1988a).

Intermittent Discharges		Later Discharges[a]	
<Grams	<Kilograms		
Ammonium bifluoride	Benzene	Copper	30 kg/mo[b]
Antimony	Carbon tetrachloride	Detergents	≤30 kg/mo[b]
Arsenic	Chromium	Ethylent glycol	≤200 L/mo
Barium	Chlorinated benzenes	Hydrofluoric acid	100 kg/mo[b]
Cadmium	Degreasing solvents	Nitrates	≤2,000 kg/mo
Dioxane	Formaldehyde	Nitric acid	≤300 L/mo
Dioxin[c]	Formic acid	Sodium hydroxide	≤300 L/mo
Hydrocyanic acid	Hexachlorophene	Paint solvents	≤100 L/mo
Pyridine	Kerosene	Photo chemicals	≤700 L/mo[b]
Selenium & compounds	Lead	Sodium chloride	75 tons/yr
Thiourea	Methy ethyl ketone	Uranium	20 kg/mo[b]
Misc. laboratory chemicals	Mercury	Perchloroethylene	450 L[d]
	Napthalene	Heating oil	300 L[d]
	Nickel		
	Phenol		
	Silver		
	Sulfuric acid		
	Tetrachloroethylene (perchlorethylene)		
	Toluene		
	Tributylphosphate (paraffin hydrocarbon solvents)		
	1,1,1-Trichloroethane (methyl chloroform)		
	Trichloroethylene		
	Xylene		

[a]These discharges were relatively continuous.
[b]Discharged at least through 1988.
[c]Included only because of the potential for dioxin to exist as a trace impurity in chlorinated benzenes.
[d]Known spills.

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beginning of operations in 1975 until October 1993, a continuous, composite sampler was located at the headwall to analyze the wastewater at the point of discharge to the trenches. Since 1993, the effluent has been analyzed by a sampler located outside the unit.

In 1991 an ERA was undertaken at the 300 APT. This action was initiated because of concerns about analytical results of trench sampling in 1986 (DOE-RL 1990, Table 15). The ERA objective was to reduce the potential migration of contaminants in the soil at the bottom of trenches to groundwater. The specific ERA goal was to reduce the measurable level of radiation in the trenches to less than three times the upper tolerance limit of background. This was accomplished by removing contaminated sediments, using them to fill in the north end of the trenches, and immobilizing them. In the process much of the inorganic constituents (including heavy metals) were removed as well (DOE-RL 1992).

Approximately 5,400 m^3 (7,000 yd^3) of sediment were removed f[illegible] trench and relocated to the north ends of the trenches. About [illegible] of chemically and radioactively contaminated soil from the sides [illegible] 1.3 m (4 ft) from the bottom of each trench were removed. The [illegible]vely contaminated sediments (<2,000 cpm) were relocated to the n[illegible] end of each trench. The more radioactively contaminated sediments (>2,[illegible] cpm) were consolidated in the depression located at the northwest corner of the west trench. Contaminated soils in the depression were isolated from the effluent and then covered with a plastic barrier and a layer of clean aggregate. Results of pre- and post-ERA sampling and analysis (DOE-RL 1992) indicate that the ERA successfully reduced trench contamination at all areas of the trenches other than the position where contaminated soils were stockpiled. Results of groundwater sampling and analysis after the ERA also show a drop in constituents of concern. As an example, uranium concentrations in well 399-1-17A declined following ERA (see Section 3.3).

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3.0 HYDROGEOLOGY AND GROUNDWATER MONITORING RESULTS

Information about geology, groundwater hydrology, and groundwater contamination in the vicinity of the 300 APT has been derived predominantly from wells. Since the first 300 Area groundwater monitoring well was installed in 1943 (399-3-6), many additional wells of a variety of construction types have been installed to monitor the groundwater and characterize the geology. Most wells fit into one of two types: (1) a pre-1985 type that is nominal 0.15 to 0.30 m (6 in. up to 12 in. diameter) carbon steel casing that was perforated (early design) or screened (later design) in the saturated zone and (2) a 1985 to recent type that meets the requirements of WAC 173-160, *Minimum Standards for Construction and Maintenance of Wells* (REFERENCE). These more modern regulatory-compliant wells have nominal 10-cm (4-in.) stainless steel casing with stainless steel, wire-wrap screens in the saturated zone, and extensive annular and surface seals. Figure 3-1 is a map of the 300 Area showing well locations. Table 3-1 provides well construction details.

3.1 GEOLOGY

This section summarizes the geology in the vicinity of the 300 APT. More detailed discussions are found in Lindberg and Bond (1979), Schalla et al. (1988b), Delaney et al. (1991), Gaylord and Poeter (1991), and Swanson et al. (1992). From youngest to oldest, the geologic units found beneath the 300 Area are:

- Holocene surficial deposits
- Hanford formation
- Ringold Formation
- Saddle Mountains Basalt

These units are discussed in the following sections.

A stratigraphic column (Figure 3-2) and a series of geologic cross sections (Figures 3-3 through 3-6) show the distribution and characteristics of geologic units within the 300 Area. The 300 Area is located within one of the broad, flat synclines (Pasco syncline) within the larger Pasco Basin. The basalts and overlying sediments are essentially horizontal. The following sections discuss the geologic units beneath the 300 Area in more detail.

3.1.1 Holocene Surficial Deposits

Holocene surficial deposits in the vicinity of the 300 Area include eolian sandy silts and fluvial deposits associated with the Columbia River. The eolian deposits are in the form of thin (0 to 2 m [0 to 6.6 ft]) sheets and thicker (2 to 5 m [6.6 to 16 ft]) dunes. Dunes are especially well developed and remain active in the area to the north of the 300 Area. Inside the perimeter fence of the 300 Area the eolian deposits are mostly absent or reduced in thickness as a result of construction activities. Recent fluvial deposits such as overbank silts and channel deposits of sand and gravel are found in areas immediately adjacent to the Columbia River.

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Figure 3-1. Location Map of 300 Area Wells.

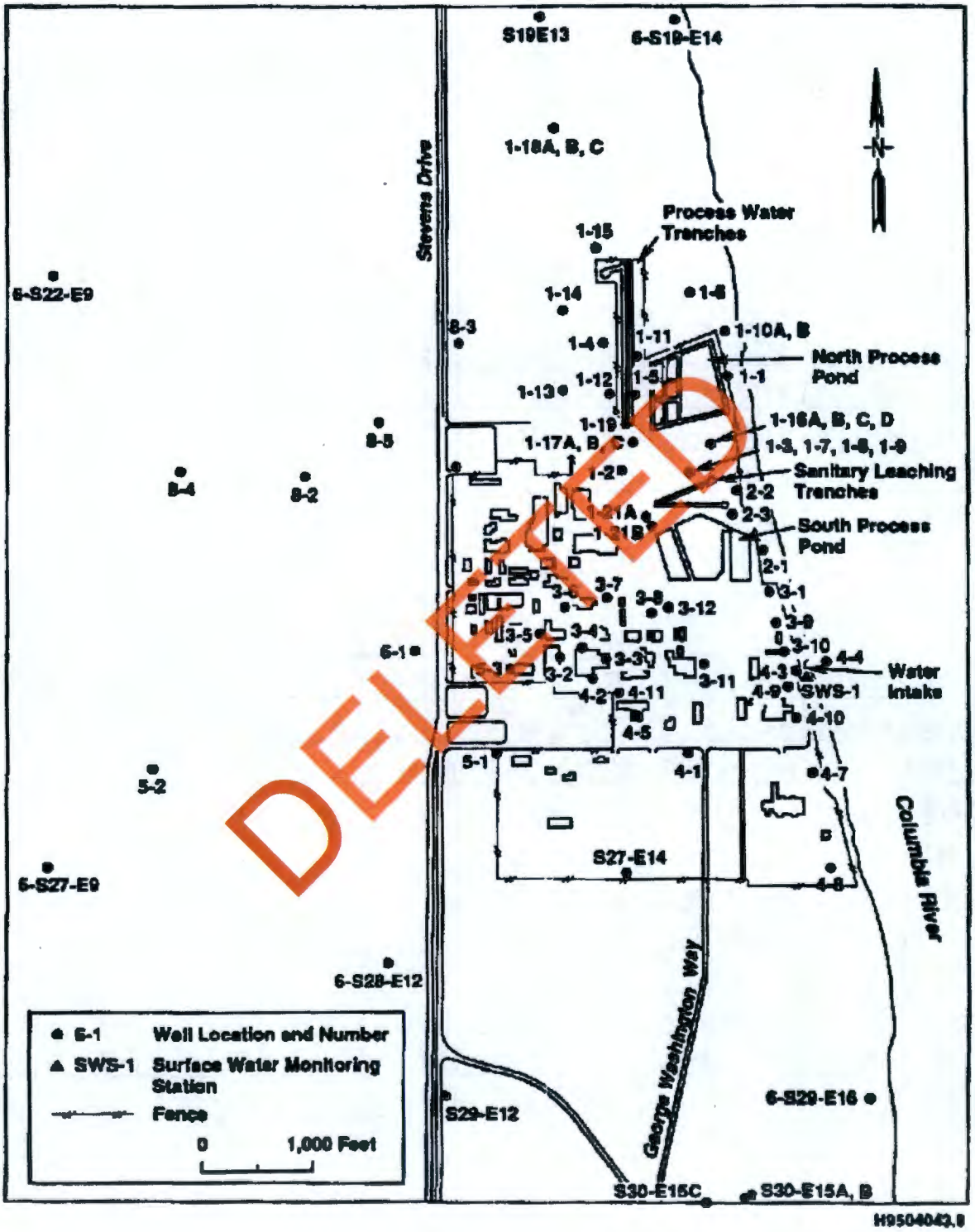

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Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
Original 16 Wells in Groundwater Monitoring Plan (Schalla 1988b)							
699-S19E13	11/71	50	51	78	P	TU	N
399-1-6	2/75	22	33	43	S	TU	N
399-1-4	5/50	23	38	70	P	TU	N
399-1-5	2/75	23	35	45	S	TU	N
399-1-1	11/48	40	33	75	P	TU	N
399-8-2	5/50	43	50	72	P	TU	N
399-1-2	4/50	25	42	75	P	TU	N
399-1-3	4/50	25	34	70	P	TU	N
399-1-7	3/85	25	37	70	S	TU	N
399-1-8	8/85	85	40	105	S	BU	N
399-2-1	11/48	18	34	75	P	TU	N
399-3-7	1/44	45	--	60	P	TU	N
399-3-10	9/76	34	40	49	S	TU	N
399-4-1	2/51	25	50	80	P	TU	N
399-4-7	11/61	21	36	46	P	TU	N
699-S30E15A	10/71	58	65	78	S	TU	N
Wells Completed in 1986 and 1987 in Response to the *Tri-Party Agreement*							
399-4-11	11/26/86	55	63	70	S	TU	Y
399-1-9	2/12/87	170	10	178	S	C	Y1
399-1-10A	12/23/86	23	31	39	S	TU	Y2
399-1-11	11/20/86	26	35	47	S	TU	Y
333-1-12	11/3/86	45	42	60	S	TU	Y
399-1-13A	11/5/86	38	46	53	S	TU	Y2
399-1-14A	11/14/86	31	39	47	S	TU	Y2
399-1-15	11/17/86	29	36	44	S	TU	Y
399-1-16A	12/5/86	32	39	48	S	BU	Y2
399-1-16B	2/10/87	105	38	115	S	C	Y
399-1-16C	1/16/87	167	40	178	S	TU	Y
399-1-17A	11/13/86	25	35	40	S	BU	Y

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Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
399-1-17B	12/19/86	100	33	110	S	C	Y
399-1-17C	1/16/87	161	3	171	S	TU	Y
399-1-18A	11/12/86	38	47	54	S	BU	Y2
399-1-18B	1/23/87	109	43	119	S	C	Y
399-1-18C	1/6/87	130	45	140	S	TU	Y
399-1-19	5/23/86	--	33	--	--	TU	N1
Miscellaneous Wells							
399-1-10B	10/8/91	105	38	115	S	BU	Y
399-1-14B	10/31/91	99	38	110	S	BU	Y
399-2-2	10/3/76	35	39	55	S	TU	N
399-2-3	10/4/76	45	40	55	S	TU	N
399-3-1	10/26/48	20	40	65	P	TU	N
399-3-2	10/13/47	40	51	75	P	TU	N
399-3-3	2/9/48	52	51	81	P	TU	N
399-3-6	8/43	42	49	55	P	TU	N
399-3-8	3/17/70	28	44	48	P	TU	N
399-3-9	8/30/76	45	55	55	S	TU	N
399-3-11	9/17/76	45	53	65	S	TU	N
399-4-9	9/26/76	38	38	58	S	TU	N
399-4-10	9/27/76	30	34	50	S	TU	N
399-5-1	2/19/51	23	51	58	P	TU	N
399-6-1	6/2/50	25	45	50	P	TU	N
399-8-1	6/6/50	35	52	60	P	TU	N

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Table 3-1. Characteristics of 300 Area Wells. (3 sheets)

Well	Completed	T	WL	B	S/P	Aquifer	WAC
399-8-3	3/7/51	25	50	72	P	TU	N
699-S27-E14	4/15/48	45	58	1005	P	TU	N
699-S29-E12	11/5/71	59	38	79	S	TU	N

Aquifer = Which aquifer screened or casing perforated in which aquifer?
B = Depth to bottom of screen or perforations in feet.
BU = Bottom of unconfined aquifer.
C = Confined aquifer.
Completed = Completion date.
N1 = Carbon steel casing, not perforated or screened, open at hole bottom.
P = Access to aquifer through perforations in casing.
S = Access to aquifer through well screen.
S/P = Screen or perforations in carbon steel casing?
T = Depth to top of screen or perforations in feet.
TU = Top of unconfined aquifer.
WAC = Well construction complies with WAC 173-160?
WL = Depth to water in feet.
Y/N = Yes/No.
Y1 = Well has a 10-in. carbon steel casing that was left in hole to 100 ft.
Y2 = Two screens, telescoping screen left in hole.

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Figure 3-2. Generalized Geologic Column for the 300 Area Near the Process Trenches.

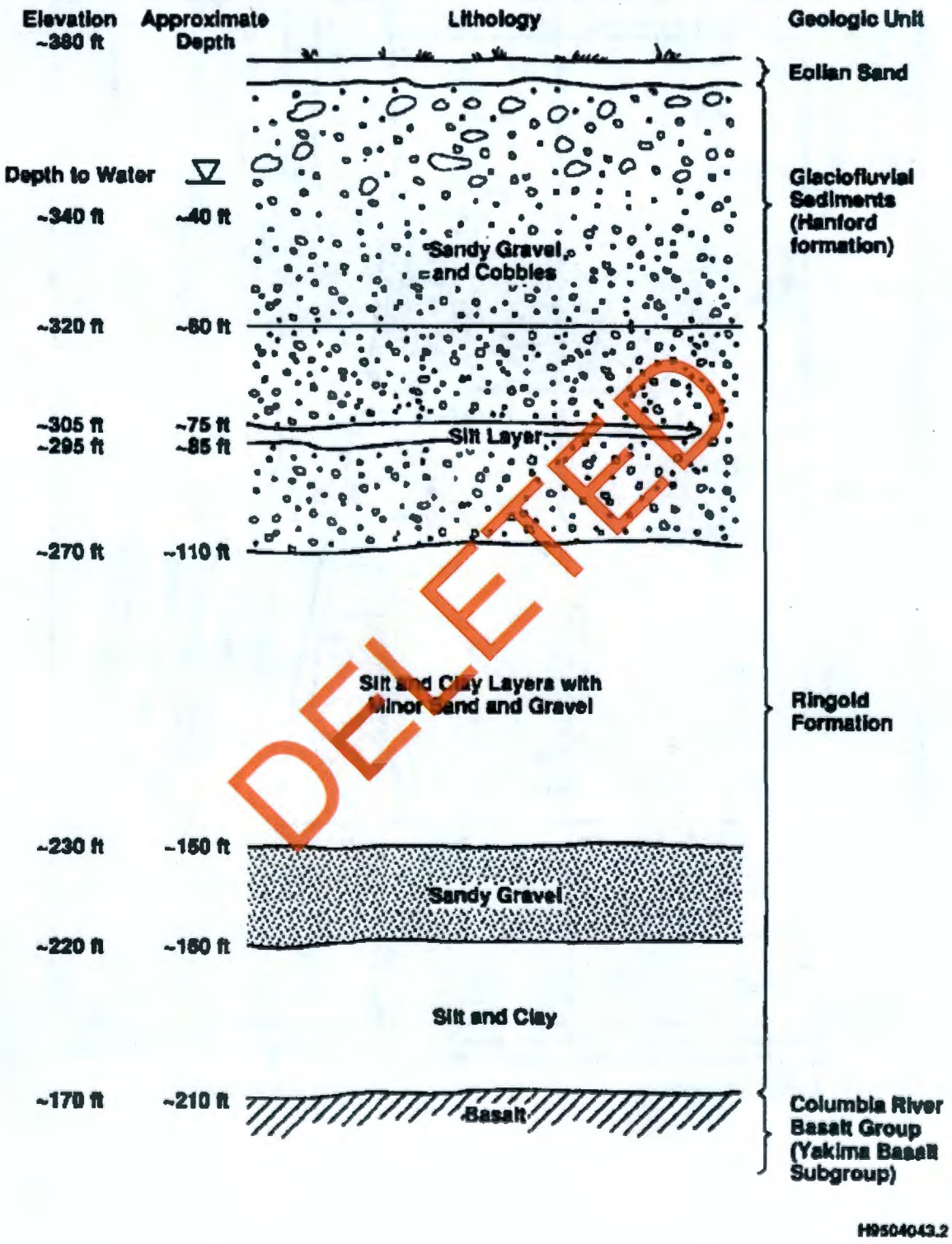

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Figure 3-3. Location Map for the Geologic Cross Sections.

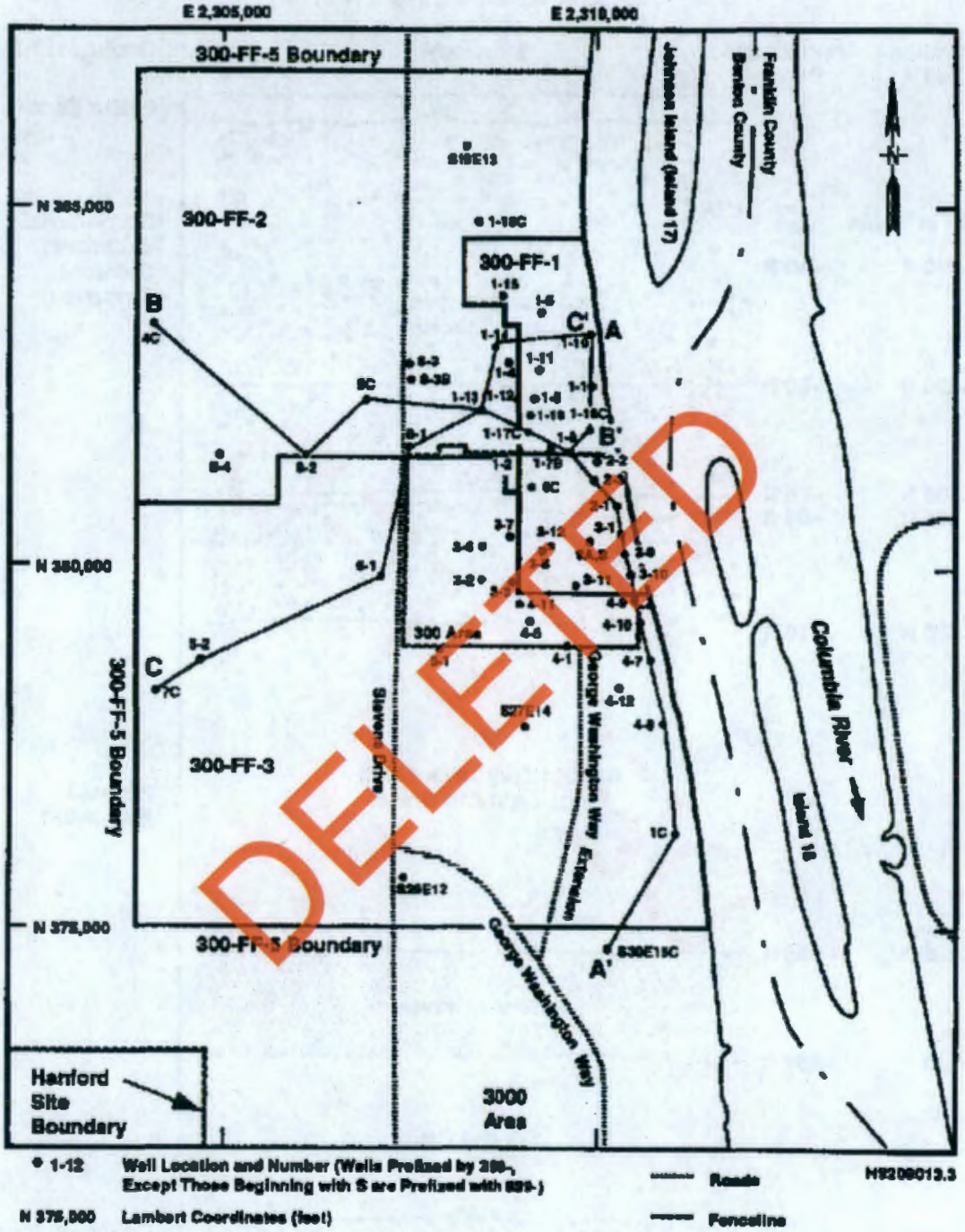

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Figure 3-4. Geologic Cross Section A-A'.

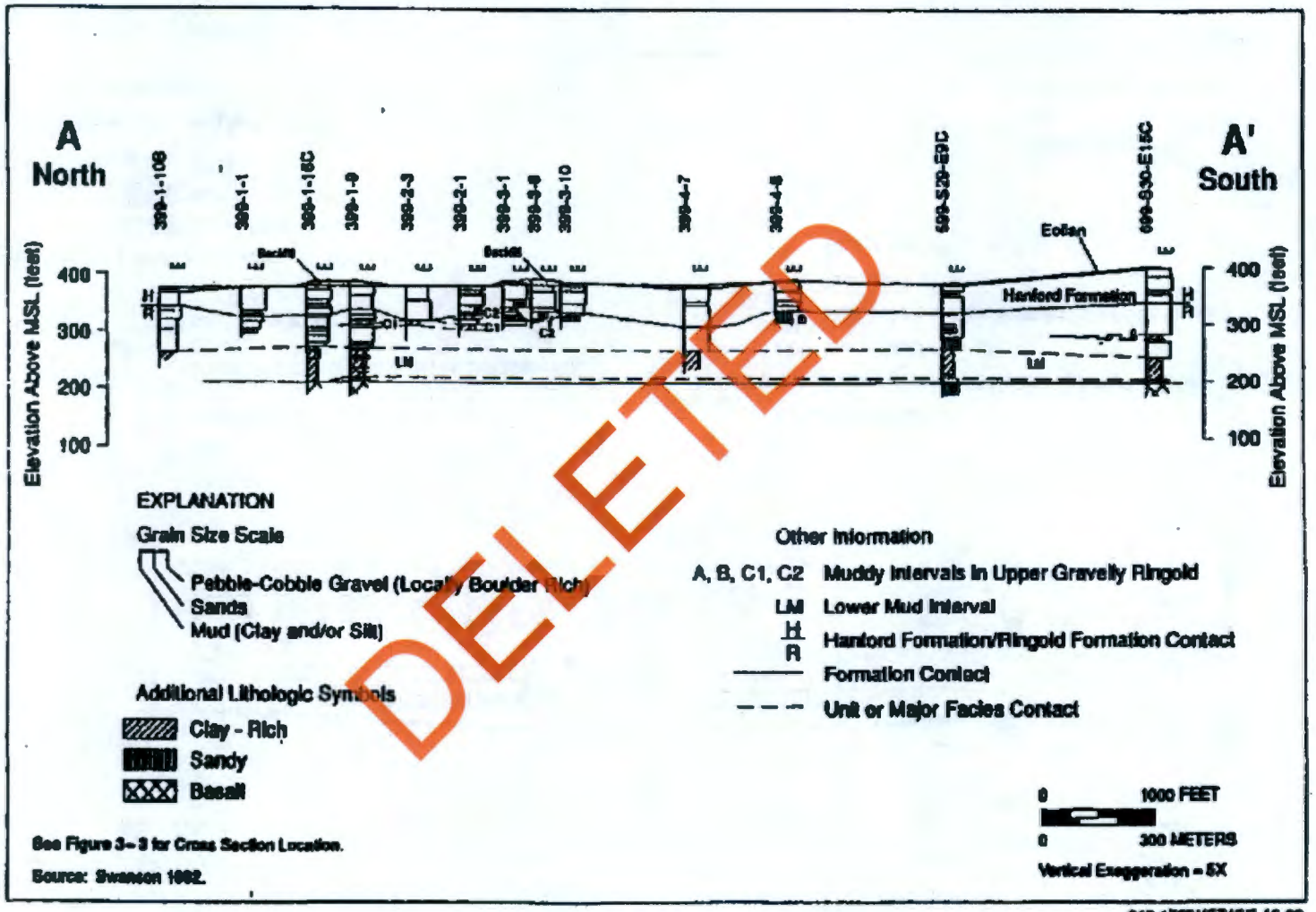


Figure 3-5. Geologic Cross Section B-B'.

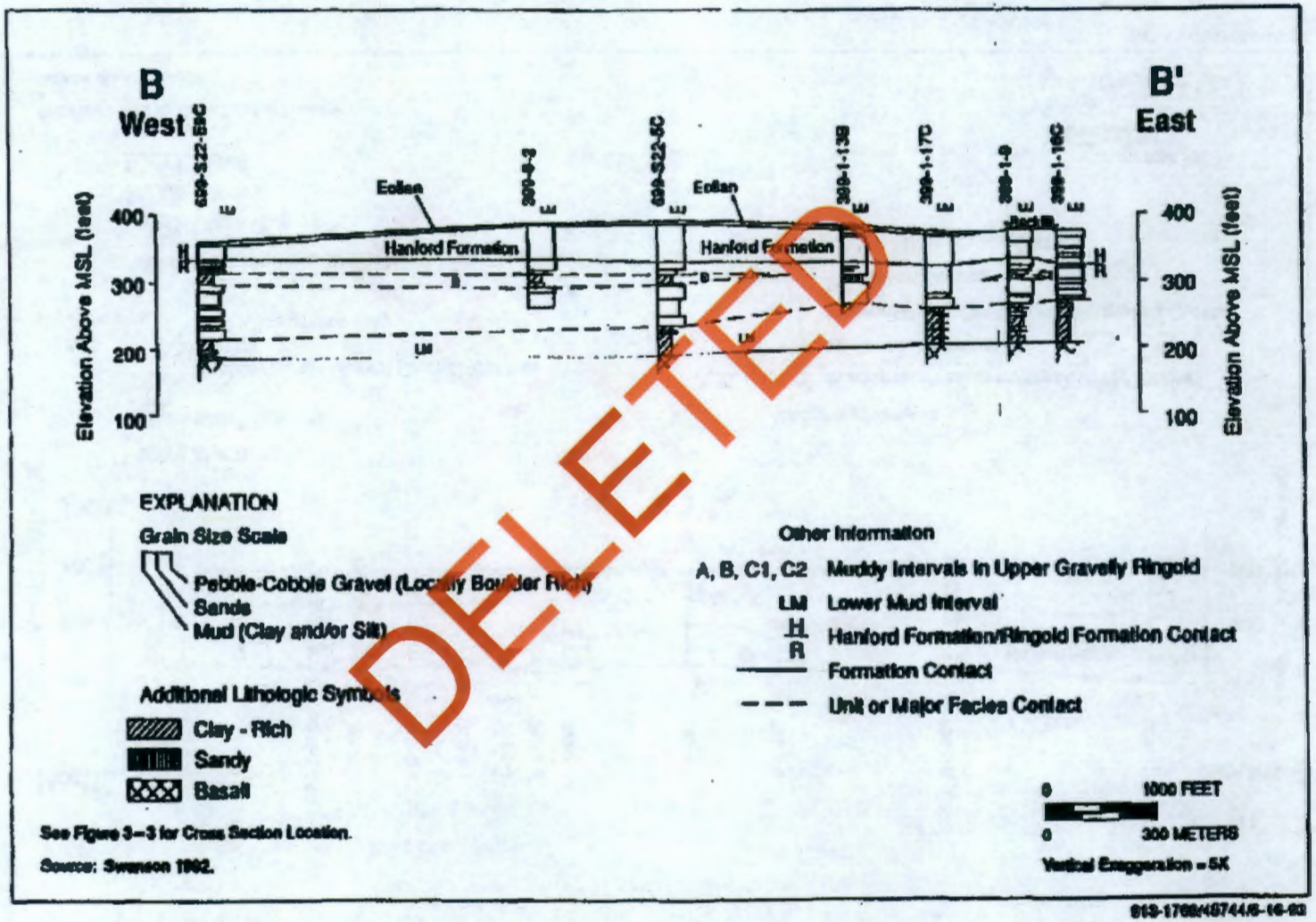
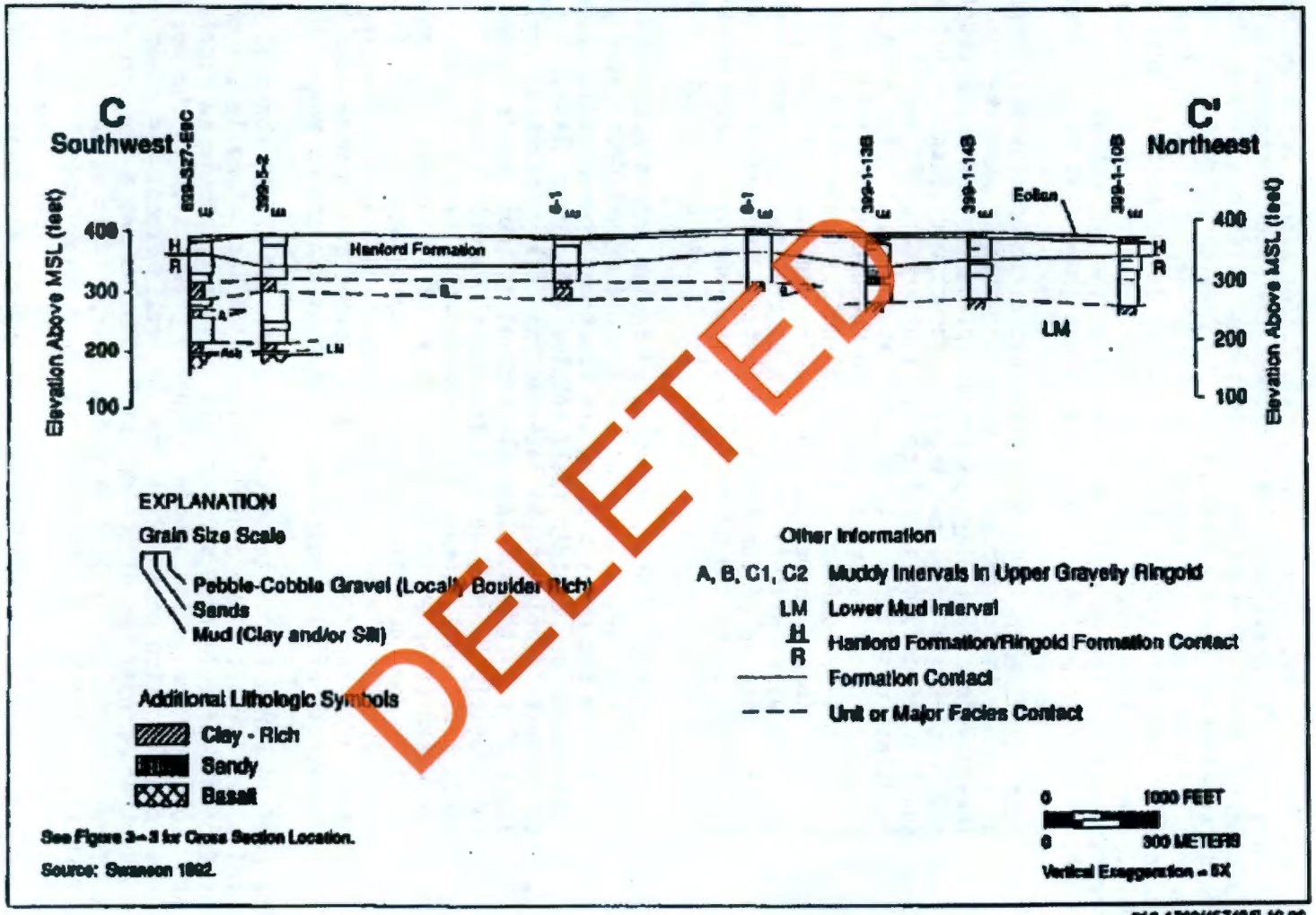


Figure 3-6. Geologic Cross Section C-C'.



3.1.2 Hanford Formation

Delaney et al. (1991) discuss three main facies associated with the Hanford formation: (1) gravel-dominated facies, (2) sand-dominated facies, and (3) slackwater deposits composed of interbedded silts and fine sands. The Hanford formation in the vicinity of the 300 Area contains two of the three facies, (1) first and (2) second. Slackwater deposits composed of interbedded silts and fine sands, the third facies discussed in Delaney et al. (1991), are absent, although silts occasionally occur as minor portions of the other two facies. The main characteristics of the two facies that comprise the Hanford formation in the 300 Area are summarized as follows:

1. Gravel-dominated. The gravel-dominated facies generally consists of granule to boulder gravel with a dominantly sandy matrix. These sediments display massive and planar to low-angle bedding, and large-scale scour cut-and-fill structures (such as channels) and foreset bedding in outcrops. They are usually matrix poor and sometimes display open-framework texture. Lenticular sand and silt beds sometime are intercalated throughout the facies. Gravel clasts are predominantly basalt (50-80%). Other clast types include Ringold Formation and Plio-Pleistocene unit rip-ups, coarse-grained plutonic rocks such as granites, and metamorphic clasts composed of quartzite and gneiss. The gravel-dominated facies was deposited by relatively high-energy floodwaters within main channelways associated with Pleistocene cataclysmic flooding.

2. Sand-dominated. The sand-dominated facies is characterized by fine- to coarse-grained sand and granule gravel displaying plane lamination and cross bedding and sometimes channel-fill sequences. These sands may contain small pebbles and rip-up clasts in addition to pebble-gravel interbeds and silty interbeds less than 1 m (3.3 ft.) thick. The silt content of these sands is variable, but where it is low, an open framework texture is common. These sands are usually composed of predominantly basaltic grains and are often referred to as black, gray, or salt-and-pepper sands. The sand-dominated facies was deposited adjacent to main flood channelways during the waning stages of cataclysmic flooding or in areas of reduced velocity as water spread out in more open areas downstream of flow restrictions such as canyons or channelways.

The Hanford formation in the vicinity of the 300 APT is about 15.2 m (50 ft) thick and is mostly the gravel-dominated facies. Locally the gravel-dominated facies can be further divided into two types, pebble to cobble gravel and boulder gravel. The pebble to cobble gravel type is the most abundant Hanford formation sediment in the 300 Area. Except for minor interbedded strata consisting of boulder-rich deposits and a few sand-rich horizons (sand-dominated facies), this sediment type makes up the bulk of the Hanford formation. The boulder-rich gravels are distinguished from the pebble to cobble gravels on the basis of increased boulder content. Boulder-rich gravels contain greater than approximately 25% boulder-sized clasts (>25.6 cm [>10 in.] diameter). The thickest occurrence of boulder-rich gravels in the 300 Area is found between boreholes 399-1-16ABC and 399-3-9 where up to 18 m (60 ft) of such strata have been logged. These gravels do not extend west of boreholes 399-1-17ABC, although they may extend to the southwest. A second

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boulder-rich zone up to 6 m (20 ft) is located at or near the uppermost portions of the Hanford formation in the southern portion of the 300 Area, and a third one occurs in the northernmost part of the 300 Area. The first and second zones may interfinger near wells 399-3-3, 399-2-3, and 399-2-1, but the third zone appears to be separate from the other boulder-rich zones by pebble to cobble gravels.

The sand-dominated facies of the Hanford formation in the 300 Area consists largely of basaltic coarse-grained sand and granules with an open-framework texture. Silt content is low. Thick occurrences of this facies are rare in the 300 Area, and the thinner horizons that do occur are too thin to be easily shown on the cross sections (Figures 3-4 to 3-6). However, thin beds of the sand-dominated facies are common and often intercalated with layers in the pebble to cobble gravel of the gravel-dominated facies.

3.1.3 Ringold Formation

The Ringold Formation near the 300 APT is about 37 m (120 ft) thick and contains three of the five Ringold Formation facies. The three occurring Ringold Formation facies are (1) fluvial gravel, (2) overbank deposits, and (3) lacustrine deposits. These facies are described in detail in Delaney et al. (1991) and Lindsey (1991). They can be summarized as follows:

1. Fluvial gravel. Clast-supported granule-to-cobble gravel with a sandy matrix dominates the facies. Intercalated lenses of sand and mud are common. Clast lithologies are dominated by quartzite and basalt with subordinate lithologies including silicic plutonic rock, intermediate to silicic volcanic rocks, gneiss, volcanic breccias, and greenstone. Matrix sand is sublithic, subarkosic, and arkosic with the feldspars being dominated by plagioclase. Sand beds in the association generally are quartz-felspathic, with basalt content usually ranging between 5% and 25%. Low-angle to planar stratification, massive bedding, wide shallow channels, and large-scale cross bedding are found in outcrops. Compaction and cementation are highly variable with most cementation consisting of $CaCO_3$ and iron oxides. The association was deposited in a gravelly fluvial braidplain characterized by wide, shallow, shifting channels.

2. Overbank deposits. This facies dominantly consists of laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of pedogenic calcium carbonate. Overbank deposits occur as thin (<0.5 to 2 m [1.6 to 6.6 ft]) lenticular interbeds in the fluvial gravel facies and as thick (up to 10 m [33 ft]) laterally continuous sequences. These sediments record deposition in proximal levee to more distal floodplain conditions.

3. Lacustrine deposits. Plane laminated to massive clay with thin silt and silty sand interbeds displaying some soft-sediment deformation characterize this association. Coarsening upward sequences less than 1 to 10 m (3.3 to 33 ft) thick are common. Strata comprising the association were deposited in a lake under standing water to deltaic conditions.

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Ringold Formation strata in the 300 Area are generally divided into a lower, mud-dominated sequence and an upper, gravelly sequence (Figures 3-4 to 3-6). The lower 17 m (55 ft) composed of mud is laterally extensive and consists of lacustrine deposits overlying overbank deposits. It is correlated to the lower mud sequence found elsewhere throughout the Pasco Basin near the bottom of the Ringold Formation. The gravelly sequence overlying the lower mud sequence is composed dominantly of the fluvial gravel facies and is roughly correlated to Ringold Formation gravel units (B, C, and E) (Delaney et al. 1991, Lindsey 1991).[1] Two mud-dominated intervals are found in the upper gravel sequence in the 300 Area. They are discontinuous, pinch out, and are not found in the immediate vicinity of the 300 APT. However, they do occur to the west and south and consist dominantly of paleosols typical of overbank deposits.

There is evidence of erosion and channelization of the top of the Ringold Formation throughout the 300 Area (Lindberg and Bond 1979, Schalla et al. 1988b, and Swanson et al. 1992). These channels cause the upper Ringold Formation surface (and overlying Hanford gravels) to be lower by approximately 3 to 9 m (10 to 30 ft) in the channels. One of these channels may occur in the vicinity of wells 399-1-17ABC and 399-1-16ABC as inferred by Lindberg and Bond (1979). However, well spacing in the 300 Area is too large to resolve structural details of these channels (such as size and orientation) on the Hanford-Ringold Formation contact.

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3.1.4 Saddle Mountains Basalt

Underlying the 52 m (or 170 ft) of Hanford and Ringold formation sediments is the Saddle Mountains Basalt. The uppermost basalt member of this formation in the vicinity of the 300 Area is the approximately 24 m (80 ft) thick Ice Harbor Member, which contains three flows that erupted from vents near Ice Harbor Dam east of Pasco, Washington (Helz 1978, Swanson et al. 1979, DOE 1988). These basalt flows are typical in that they have rubbly or scoriacious flow tops and bottoms and relatively dense interiors. Locally, these flows have an abundant amount of palagonite indicating they were in contact with wet conditions as they were emplaced. Underlying the lowest Ice Harbor Member flow is the Levey interbed, which is one of the intercalated members of the Ellensburg Formation. The Levey interbed locally is about 5 m (or 17 ft) thick and, like other Ellensburg Formation interbeds, consists of a mix of volcaniclastic and silisiclastic sediments usually as sands, gravelly sands, or sandy silts. Underlying the Levey interbed is the Elephant Mountain Member (two basalt flows) and below that the Rattlesnake Ridge interbed of the Ellensburg Formation.

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[1]Note: The letters A, B, and C are also used to identify muddy units on the geologic cross sections (Figures 3-4, 3-5, and 3-6). This is a unique usage. The letters A, B, and C after Delaney et al. (1991) and Lindsey (1991) are in more widespread use and refer to gravelly units in the Ringold Formation throughout the Hanford Site.

3.2 GROUNDWATER HYDROLOGY

This section discusses the different aquifers within the suprabasalt aquifer system (Delaney et al. 1991). Aquifers below the suprabasalt aquifer system, although mentioned, are not relevant to this groundwater monitoring plan and are not discussed in detail.

3.2.1 Aquifers

Aquifers within the suprabasalt aquifer system are those that are above the uppermost, regionally extensive, confining layer (Figure 3-7). In the 300 Area the uppermost, regionally extensive, confining layer (aquitard, aquiclude) is the lower mud unit of the Ringold Formation. Other mud units (designated A, B, C on the geologic cross sections [see Figures 3-4 through 3-6]) exist within the Ringold Formation, but they are discontinuous.[2]

In the 300 Area the muds that exist above the lower mud unit pinch out and are not present below the 300 APT. Therefore, the unconfined aquifer extends from the water table (at about 10.1 m [33 ft] below ground surface) to the top of the Ringold Formation lower mud unit. Elsewhere in the 300 Area where one or more of the upper muds are present, the aquifer(s) between the partially confining mud units is (are) partially confined. In the immediate vicinity of the 300 APT the unconfined aquifer is composed of the lowermost 5 m (17 ft) of Hanford formation and approximately 20 m (65 ft) of Ringold Formation. The Hanford formation there is composed primarily of the gravel-dominated facies, and the Ringold Formation above the lower mud unit is dominantly the fluvial-gravel facies.

Aquifers below the Ringold Formation lower mud unit are completely confined. These confined aquifers include any coarse-grained Ringold Formation sediments below the lower mud unit, high permeability zones within basalt flows such as rubbly or scoriacious flow tops and bottoms, and interbeds of the Ellensburg Formation if the permeability is high. These confined aquifers are intercalated with- and confined by- dense interiors of the basalt flows.

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3.2.2 Aquifer Properties

The most recent aquifer tests and laboratory tests of borehole samples are reported in Swanson et al. 1992. The following are pertinent conclusions of the testing reported in that report.

- The best estimate for unconfined aquifer properties came from multiple-well analysis of constant discharge tests. Test results for the uppermost portion of the unconfined aquifer at well

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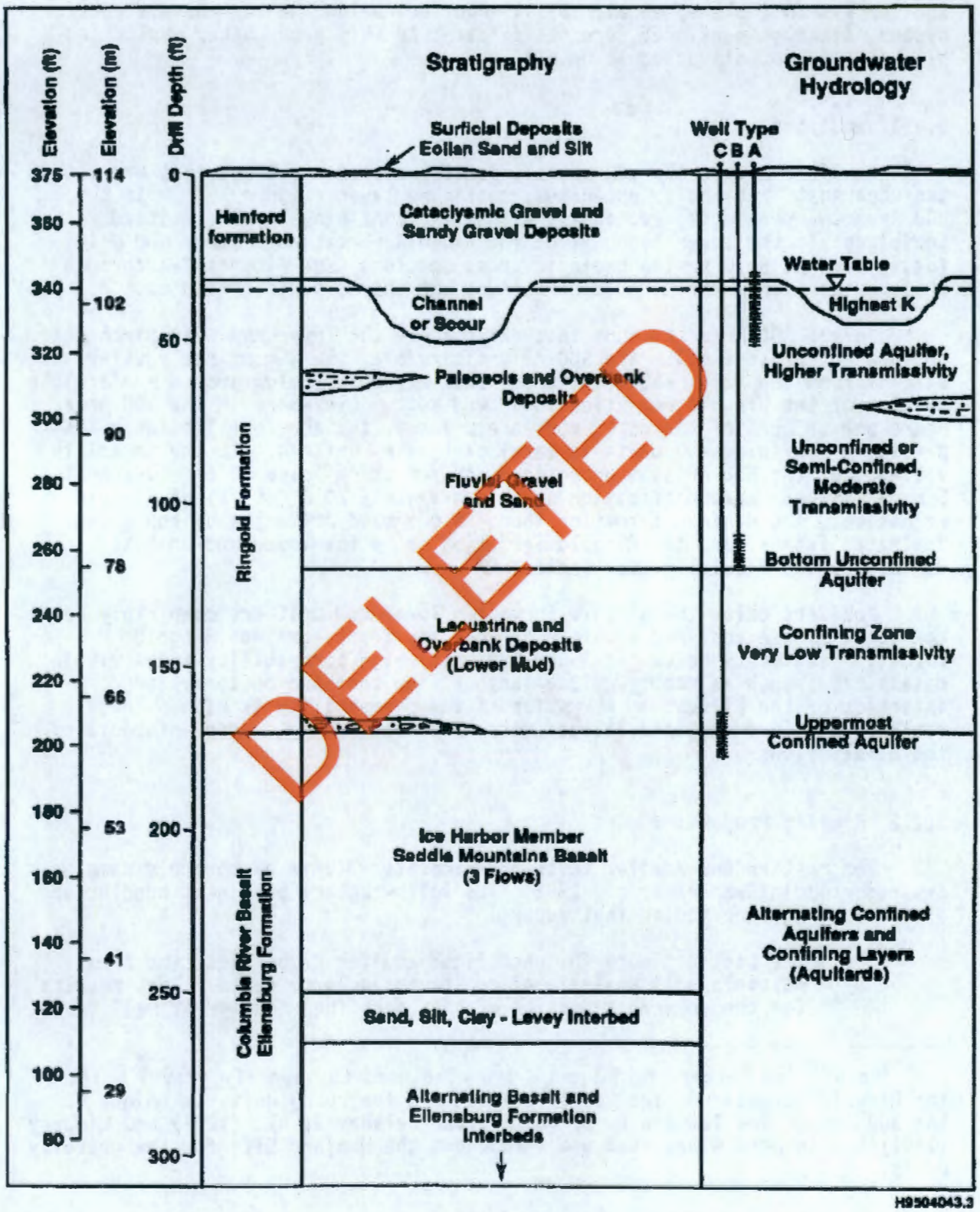
[2]Note: The letters A, B, and C are also used to identify gravel units in the Ringold Formation. The use of the letters for muddy units is unique to the 300 Area. The letters A, B, and C after Delaney et al. (1991) and Lindsey (1991) are in more widespread use throughout the Hanford Site for the gravelly units.

Figure 3-7. Generalized Hydrogeology Comparison of Geologic and Hydrologic Units in the 300 Area.



clusters 699-S22-E9ABCD and 699-S27-E9ABCD (Figure 3-1) were 36 and 49 m/d (120 and 161 ft/d) for horizontal hydraulic conductivity, 2.1 and 5.5 m/d (7 and 18 ft/d) for vertical hydraulic conductivity, 0.37 and 0.02 for specific yield, and 0.013 and 0.005 for storativity.

- Water levels measured at the two sites (cluster wells in lower Ringold Formation confined aquifer, lower unconfined aquifer, and upper unconfined aquifer) show an upward hydraulic gradient, demonstrating that the this area is probably a discharge area for the semiconfined and confined aquifers below the unconfined aquifer. (The unconfined aquifer, in turn, discharges to the Columbia River.)

- Barometric efficiencies estimated for wells screened at the bottom of the unconfined aquifer (B wells) are 10% and 18% for the two cluster sites. For the uppermost confined aquifer (C wells) the efficiencies are 28% and 22% for the two cluster sites. These results indicate that the bottom of the unconfined aquifer, and, of course, the uppermost confined aquifer in the Ringold Formation, are at least partially confined in the vicinity of the 699-S22-E9 and 699-S27-E9 well cluster sites. (Because the two upper mud units in the Ringold Formation are missing in the vicinity of the 300 APT, the bottom of the unconfined aquifer in the vicinity of the 300 APT may not show the same results.)

- The specific yield result of 0.02 may indicate a semiconfining condition.

- Laboratory test results on split-tube samples yielded vertical hydraulic conductivities that were at least one order of magnitude lower than the best estimated horizontal values.

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The well clusters used for the aquifer testing reported in Swanson et al. (1992) are effectively screened entirely in the Ringold Formation because the water table is either at or lower than the Ringold/Hanford formation contact at those well sites. However, the water table near the 300 APT is within the Hanford formation, possibly because of channeling in the top of the Ringold Formation.

Table 3-2 shows previously collected hydraulic conductivity data derived from well pumping tests (Schalla et al. 1988b, Appendix D). These data are from wells that are closer to the 300 APT than the wells reported in Swanson et al. (1992). As expected, hydraulic conductivities at the top of the unconfined aquifer in wells near the 300 APT are higher. It is suspected that these higher hydraulic conductivities in the wells closer to the 300 APT are the result of a greater contribution of groundwater from the Hanford formation which generally has a higher hydraulic conductivity than the Ringold Formation.

Table 3-2. Hydraulic Conductivities Estimated from Aquifer Tests in Wells Near the 300 Area Process Trenches (from Schalla et al. 1988b).

Well	Hydraulic Conductivity m/d (ft/d)		Aquifer
A-Wells			
399-1-13	3353	(10,998)	Top of Unconfined*
399-1-18A	15240	(49,987)	Top of Unconfined*
399-1-16A	152	(499)	Top of Unconfined*
B-Wells			
399-1-18B	0.58	(1.90)	Bottom of Unconfined
399-1-17B	3.66	(12.0)	Bottom of Unconfined
399-1-16B Test #1	0.61	(2.00)	Bottom of Unconfined
399-1-16B Test #2	0.91	(2.98)	Bottom of Unconfined
C-Wells			
399-1-18C	1.83	(6.00)	Uppermost Confined
399-1-17C	79.2	(260)	Uppermost Confined
399-1-16C	2.72	(8.92)	Uppermost Confined
399-1-9	1.83	(6.00)	Uppermost Confined

*Top of the unconfined aquifer at this well is within the lower portion of the Hanford formation.

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3.2.3 Groundwater Flow

Groundwater flow direction in the unconfined aquifer near the 300 APT is predominantly to the east or southeast with slight changes caused by fluctuations in Columbia River stage. This determination is made from depth-to-water measurements taken monthly from 33 wells in the 300 Area. Figure 3-8 shows the elevation of the water table from September 20 to 21, 1994, during the low stage period of the Columbia River. Flow direction was to the southeast in the immediate vicinity of the 300 APT. Figure 3-9 shows the elevation of the water table June 22 to 23, 1994, when the river stage was very near the high for the year. Sometimes a localized flow reversal occurs when the river stage is higher than the water level in the unconfined aquifer. The area involved in these flow reversals depends on the elevation of the high river stage and its duration. On June 22 and 23, 1994, the reversal was only experienced along the shore of the river and inland in the area of wells 399-3-12. In the area of the 300 APT the flow direction in the unconfined aquifer remained mainly toward the southeast, but the southern portion of the 300 APT had a more south to southwesterly flow. However, if the rise in river stage is more than 1 m (3.3 ft) for a sufficient duration (a week or more) the groundwater flow direction throughout most of the area of the 300 APT can be to the south or southwest (Schalla et al. 1988b, Figure 3-12).

Previous estimates of flow direction in the unconfined aquifer near the 300 APT have been based mainly on water table maps. Water table maps of the area of the 300 APT generally show a groundwater mound or southeast-trending lobe due to the discharge of water from the trenches. This mound or lobe may have a significant effect on the direction of groundwater flow in the area. However, as of January 1995, all discharges of water to the 300 APT have ceased. If the mound or lobe due to water discharge did indeed affect groundwater flow direction while the 300 APT was in operation, then shutting off the water will have an undetermined effect that will be evident in future water table maps.

There is an upward gradient between the uppermost confined aquifer and the unconfined aquifer. At wells 399-1-17A and 399-1-17C the head difference is about 11 m (35 ft). This supports the conclusion of Swanson et al. (1992) that the 300 Area is within a discharge area for the uppermost confined aquifer, and that, if communication is established between the confined aquifer and overlying unconfined aquifer, the flow direction is upward.

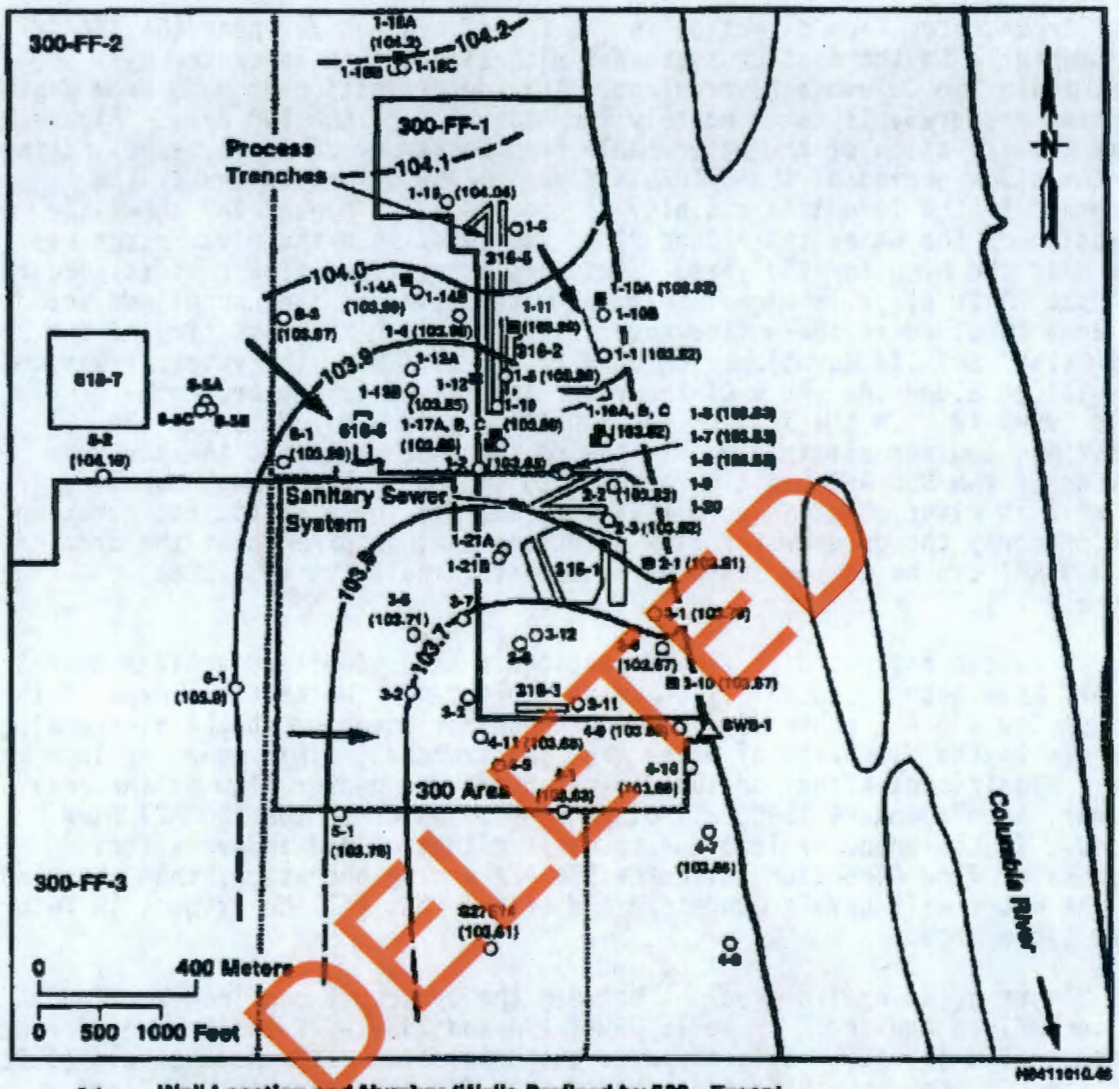
The flow rate in the top of the unconfined aquifer has been reported as about 10.7 m/d (35 ft/d) near the 300 APT based on a perchloroethylene spill (Cline et al. 1985). The rate of flow can also be estimated roughly by using the Darcy equation.

$$v = \frac{Ki}{n_e} \qquad (1)$$

where:

v = average linear groundwater velocity
K = hydraulic conductivity
i = hydraulic gradient
n_e = effective porosity.

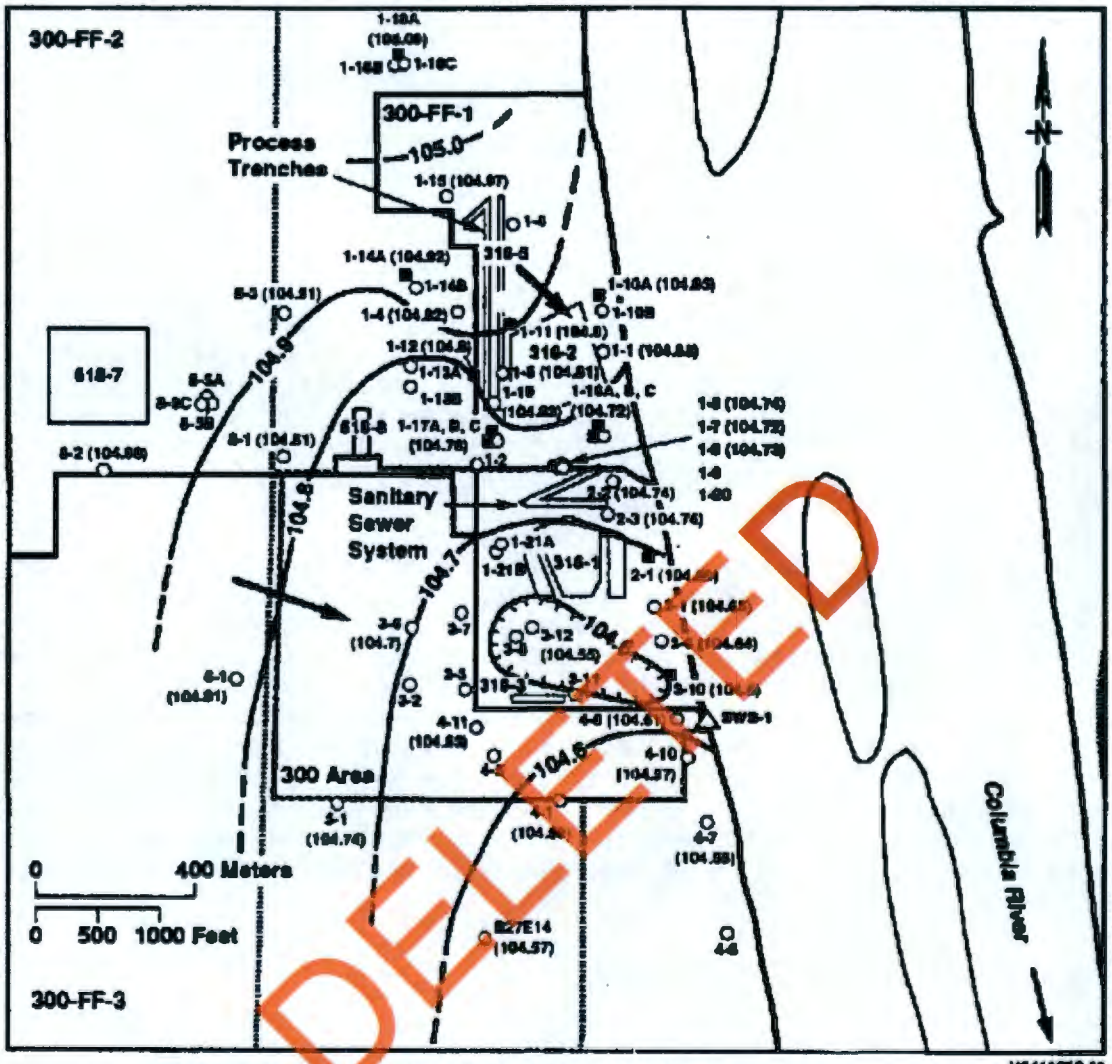
Figure 3-8. 300 Area Water Table Map, September 20-21, 1994.



○ 5-1 (103.78)	Well Location and Number (Wells Prefixed by 399-, Except Those Beginning with S are Prefixed with 699-) (Number in parenthesis is water table elevation in meters)
■ 1-12 (103.85)	Monitoring Network Well (Number in parenthesis is water table elevation in meters)
△ SWS-1	Surface-Water Monitoring Station
----------	Roads
—103.8—	Water Table Contour in Meters. Contour Interval = 0.1 Meters. (Note: Change meters to feet by multiplying by 3.28).
——►	Generalized Groundwater Flow Direction

Gradient 0.0004.

Figure 3-9. 300 Area Water Table Map, June 22-23, 1994.



○ 5-1 (104.74)	Well Location and Number (Wells Prefixed by 399-, Except Those Beginning with S are Prefixed with 699-) (Number in parenthesis is water table elevation in meters)
■ 1-14A (104.92)	Monitoring Network Well (Number in parenthesis is water table elevation in meters)
△ SWS-1	Surface-Water Monitoring Station
▬▬▬	Roads
—104.7—	Water Table Contour in Meters. Contour Interval = 0.1 Meters. (Note: Change meters to feet by multiplying by 3.28).
⟶	Generalized Groundwater Flow Direction

Gradient 0.0003.

Schalla et al. (1988b) reported values of hydraulic conductivity for the unconfined aquifer in the vicinity of the 300 APT from 150 to 15,000 m/d (500 to 50,000 ft/d) (Table 3-2). Swanson et al. (1992) reported hydraulic conductivities for the Ringold Formation as 36 and 49 m/d (120 and 161 m/d) for two well sites southwest of the 300 APT. The hydraulic gradient near the 300 APT was 0.0003 for the water table depicted in Figure 3-9 (June 22-23, 1994) and 0.0004 for the water table depicted in Figure 3-8 (September 20-21, 1994). Estimates of effective porosity for the unconfined aquifer range from 0.10 and 0.30. Using the above-stated values for input parameters to the Darcy equation, the range of average linear groundwater velocity is 0.036 m/d (0.11 ft/d) to 61.0 m/d (200 ft/d). The large range in flow velocity values is a result of the large range in values of hydraulic conductivity reported for the aquifer. If it is assumed that the Hanford formation is a major contributor to the hydraulic conductivity parameter in the vicinity of the 300 APT (because of the presence of channels that cause the water table to be within the Hanford formation), then the average flow velocity may be closer to the upper portion of the range, which is supported by the estimate of Cline et al. (1985).

The estimates of groundwater flow rate are based on aquifer conditions in the vicinity of the 300 APT when at least 800 L/min (215 gal/min) are discharged to the trenches. However, flow rates in the future may be much lower than those calculated, since wastewater discharges to the trenches have ceased. After discharges cease, the entire volume of groundwater available in the unconfined aquifer near the trenches must come through the less permeable Ringold Formation sediments upgradient (northwest) of the trenches. Without the mounding effect due to 300 APT discharge, the water table gradient may decrease enough to significantly lower the flow rate (DOE-RL 1995c). Water table maps constructed in the future, after the local unconfined aquifer has adjusted to the lack of 300 APT discharges, will be helpful in determining any significant change in gradient.

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3.3 GROUNDWATER CONTAMINATION HISTORY

3.3.1 Geohydrology and Ground-Water Quality Beneath the 300 Area, Hanford Site, Washington (Lindberg and Bond 1979)

The earliest major study of groundwater contamination in the 300 Area is reported in Lindberg and Bond (1979). In that study, groundwater samples were collected monthly for one year (during calendar year 1977) from 29 wells in the 300 Area (see Figure 3-10). The samples were analyzed for the following constituents.

Radioactive Constituents	Nonradioactive Constituents
Gross alpha	Bicarbonate
Gross beta	Carbonate
Gamma scan	Calcium
Uranium	Magnesium
Tritium	Sodium
	Chloride
	Sulfate
	Nitrate
	Chromium
	Copper
	Potassium
	Fluoride
	pH
	Specific conductivity

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The 29 wells in the sampling network at that time were all constructed of perforated carbon steel casing with dedicated submersible electric pumps. This well type does not meet current regulatory standards (WAC 173-160).

Results showed that calcium, magnesium, sodium, bicarbonate and sulfate were lower in concentration near the 300 APT than in background wells (dilution). Constituents that were found to be in higher concentrations near and downgradient of the 300 APT were gross alpha, uranium, chloride, and nitrate. Presumably, discharges to the trenches were responsible for the constituents with higher concentrations.

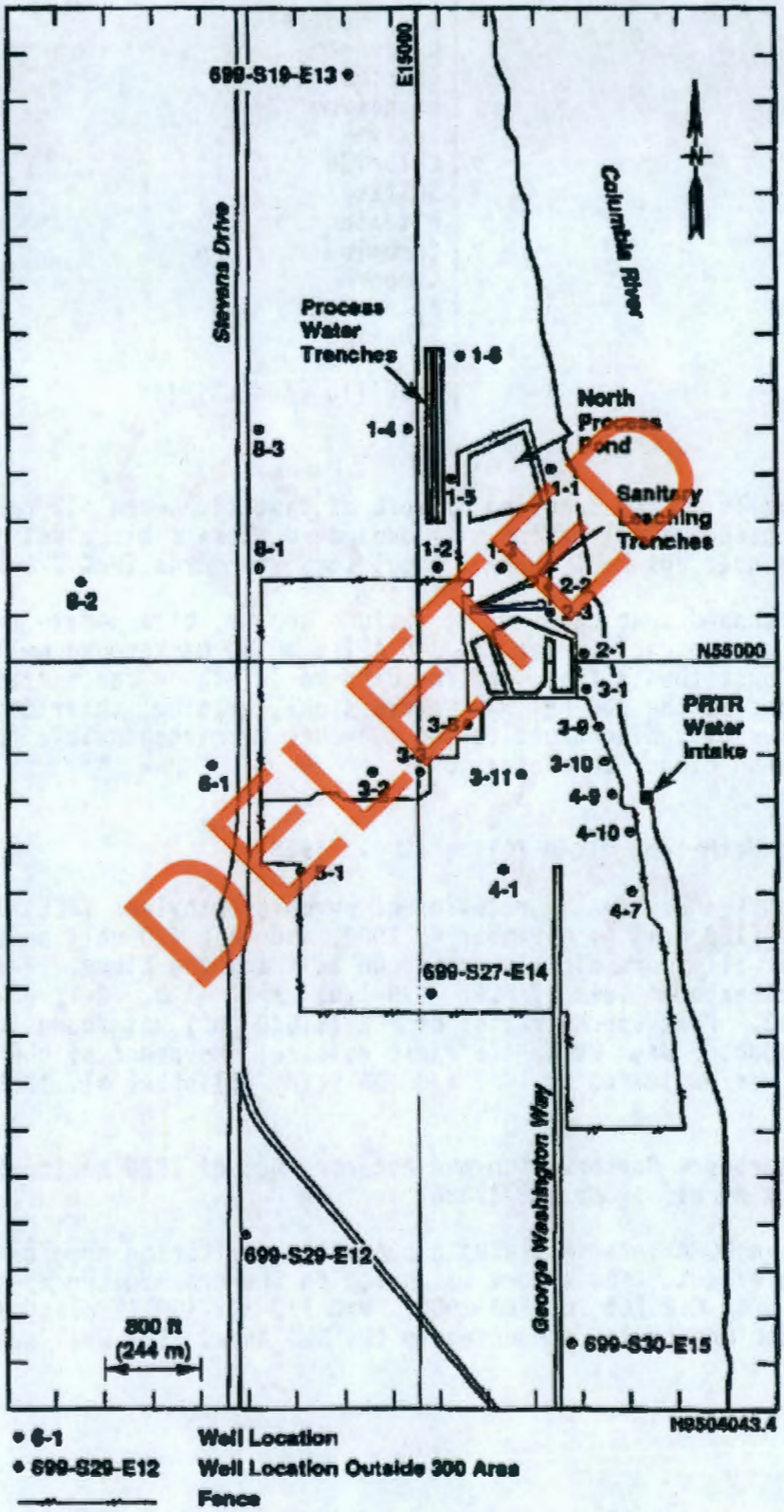
3.3.2 Perchloroethylene Plume (Cline et al. 1985)

Following two accidental releases of perchloroethylene (PCE) to the 300 APT (454 L [120 gal] on November 4, 1982, and 76 L [20 gal] on July 6, 1984), several wells were closely monitored to track the plume. The following wells showed elevated levels of PCE: 399-1-5, -1-2, -1-3, -2-1, -2-2, -3-1, -4-7, and -4-10. Peak concentration of PCE (1,840 ppb) was found in well 399-1-5 about 5 days after the first release. Movement of the peak concentration was estimated at 10.7 m/d (35 ft/d) (Cline et al. 1985).

3.3.3 Early Resource Conservation and Recovery Act of 1976 Monitoring (Schalla et al. 1988a and 1988b)

By 1985, a RCRA interim-status groundwater monitoring program for the 300 APT was in effect. The effort was based on the groundwater monitoring requirements in 40 CFR 265.90 (EPA 1984), WAC 173-303-400 (Ecology 1986), and past groundwater monitoring conducted in the 300 Area. The well network,

Figure 3-10. Location Map for Wells Used in the Study by Lindberg and Bond 1979.



which was sampled monthly, consisted of the following 16 wells. Fourteen monitored the upper portion of the unconfined aquifer and two (399-1-8 and -4-1) monitored the base of the unconfined aquifer. The wells are shown on Figure 3-1):

399-1-1	399-1-5	399-2-1	399-4-10
399-1-2	399-1-6	399-3-7	399-8-2
399-1-3	399-1-7	399-3-10	699-S19-E13
399-1-4	399-1-8	399-4-1	699-S30-E16A

Six of the wells have stainless-steel screens, and the other 10 have perforated casings (Table 3-1).

Based on instructions given in *Test Methods for Evaluating Solid Waste* (EPA 1986) and information provided by the facility manager concerning the composition of the wastes, the constituents listed in Table 3-3 were analyzed in the groundwater samples collected from the 16 wells. The U.S Environmental Protection Agency (EPA) guidance suggested that analyses should be conducted for the Primary Drinking Water Standards (DWS) and for specific dangerous waste constituents known to have been discharged to the unit. Additional parameters, such as the contamination indicator parameters that are required for a detection-level program (but not necessary for an alternate or assessment-level program), were added to provide consistency with other interim-status programs. In addition, samples from two wells sampled quarterly were also being analyzed for some additional parameters, including the dangerous waste constituents in WAC 173-303-9905 (Ecology 1986). These additional analyses (Table 3-4) provided information needed for the permitting process and to further ensure that potential contaminants are not being overlooked. The two wells chosen for the extra analyses included one upgradient well (699-S19-E13) and one downgradient (399-1-3).

The dangerous waste constituents list in WAC 173-303-9905 is very similar to the Appendix IX list of 40 CFR 264, Subpart F. However, there are some differences. Those constituents in Appendix IX that are not in WAC 173-303-9905 are listed in Table 3-6. All of the constituents listed in Table 3-6 were analyzed later in all 11 of the wells of the current 300 APT program.

Results of the early analyses under the interim-status program are documented in Schalla et al. (1988a, Tables 6 and 7) and Schalla et al. (1988b). Schalla et al. (1988a), Table 6, (Summary of Constituents Sampled to Date) shows that the herbicides and pesticides on the Interim Primary DWS list were never reported above detection limits nor were the phenols in the list of water quality parameters. Very few of the constituents in the site-specific list and almost none of the additional constituents sampled as part of the WAC 173-303-9905 list were detected. Several other constituents have only been reported above detection limits sporadically. Among those constituents that are regularly reported as being above the detection limit are gross alpha, gross beta, barium, nitrate, sodium, iron, sulfate, chloride, copper, ammonium, vanadium, potassium, chloroform, and methylchloride.

Schalla et al. (1988a), Table 7, (Analytical Data, June 1988-May 1986), compiles the results for those constituents that had at least one value reported above detection limits. Gross alpha and beta both exceeded their

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Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Barium	P, HNO_3 to pH <2	SW-846, #6010	6
Cadmium			2
Chromium			10
Silver			10
Sodium			100
Nickel			10
Copper			10
Aluminum			150
Manganese			5
Iron			50
Calcium			50
Zinc			5
Arsenic	P, HNO_3 to pH<2	SW-846, #7060	5
Mercury	P, HNO_3 to pH<2	SW-846, #7470	0.1
Selenium	P, HNO_3 to pH<2	SW-846, #7740	5
Lead	P, HNO_3 to pH<2	SW-846, #7421	5
Nitrate	P, None	70-IC[e,f]	500
Sulfate			500
Fluoride			500
Chloride			500
Cyanide	P, NaOH to pH>12	SW-846, #9010	10
Sulfide	P, zinc acetate + NaOH to pH>9	SW-846, #9030	1,000
Radium	P, HNO_3 to pH<2	EPA Method #903.0	1 pCi/L
Gross alpha	P, HNO_3 to pH<2	EPA Method 680/4-75-001	4 pCi/L
Gross beta	P, HNO_3 to pH<2	EPA Method 680/4-75-001	8 pCi/L
Natural uranium[g]	P, HNO_3 to pH<2	20-U-03[h]	4 pCi/L
Strontium-90[g]	P, HNO_3 to pH<2	20-Sr-02[h]	5 pCi/L
Gamma scan[g]	P, HNO_3 to pH<2	30-GS & 40-07[h]	20 pCi/L (Cs)
Total organic halogen	G, No headspace	SW-846, #9020	100
Total organic carbon	G, H_2SO_4 to pH<2	Std. Methods #505	1,000

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Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Ammonium ion	G, H_2SO_4 to pH<2	Std. Methods #417 A-E	50
Hydrazine	G, None	70-DAI[e,k]	3,000
Endrin Methoxychlor Toxaphene Lindane (4 isomers)	G, None	SW-846, #8080[i]	1 1 1 1
2,4-D 2,4,5-TP silvex	G, None	SW-846, #8150[i]	1 1
1,1,1-trichloroethane Perchloroethylene Chloroform Methylene chloride 1,1,2-trichloroethane 1,1,2-trichloroethylene Methylethyl ketone	G, No headspace	SW-846, #8240	10 10 10 10 10 10 10
Coliform bacteria	P, None	Std. Methods #908A	2.2 MPN[j]
Temperature	Field measurement		0.1°C

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Table 3-3. Standard List of Analyses for the 300 Area Network (from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Specific conductance	Field measurement		1 µmho
pH	Field measurement		0.01 pH unit

[a]P = plastic, G = glass.
[b]All samples cooled to 4°C upon collection.
[c]Constituents grouped together within brackets are analyzed by the same method.
[d]Detection limit units except where indicated.
[e]In-house analytical method (PNL).
[f]IC = ion chromatography.
[g]Analyzed quarterly on selected wells.
[h]From US Testing Company Procedure Manual, UST-RQ-PM-9-80
[i]Analyzed on quarterly basis only.
[j]MPN = most probable number.
[k]DAI = direct aqueous injection.

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Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Beryllium	P, HNO_3 to pH<2	SW-846, #6010	5
Osmium			300
Strontium			300
Antimony			100
Vanadium			5
Potassium			100
Thallium	P, HNO_3 to pH<2	SW-846, #7840	200
Thiourea	G, None	SW-846, #8330 (modified)	200
1-acetyl-2-thiourea			200
1-(o-chlorophenyl) thiourea			200
Diethylstilbesterol			200
Ethylenethiourea			200
1-naphthyl-2-thiourea			200
N-phenylthiourea			200
DDD	G, None	SW-846, #8180	1
DDE			1
DDT			1
Heptachlor			1
Heptachlor epoxide			1
Dieldrin			1
Aldrin			1
Chlordane			1
Endosulfan I			1
Endosulfan II			1
Chlorobenzilate			100
2,4,5-T	G, None	SW-846, #8150	1
Perchlorate	P, None	70-IC[e,f]	1,000
Phosphate			1,000
Carbophenothion	G, None	SW-846, #8140	2
Tetraethylpyrophosphate			100
Disolfoton			2
Dimethoate			5
Methyl parathion			2
Parathion			2
Citrus red #2	G, None	AOAC, #34.015B	1,000

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Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Paraldehyde	G, None	DAI[e,g]	3,000
Cyanogen bromide			3,000
cyanogen chloride			3,000
acrylamide			3,000
Allyl alcohol			3,000
Chloral			3,000
Chloroacetaldehyde			3,000
3-chloropropionitrile			3,000
Cyanogen			3,000
Dichloropropanol			3,000
Ethyl carbamate			3,000
Ethyl cyanide			3,000
Ethylene oxide			3,000
Fluoroacetic acid			3,000
Glycidylaldehyde			3,000
Isobutyl alcohol			3,000
Methyl hydrazine			3,000
n-propylamine			3,000
2-propyn-1-ol			3,000
1,1-dimethyl hydrazine			3,000
1,2-dimethyl hydrazine			3,000
Acetronitrile			3,000
Tetrachloromethane	G, None	SW-846, #8240	10
Xylene-o,p			10
Xylene-m			10
Formaldehyde			500
Additional volatiles			10

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Table 3-4. Additional Analytical Parameters (modified from Schalla et al. 1988a). (3 sheets)

Constituent	Collection[a] and Preservation[b]	Method[c]	Detection Limit, ppb[d]
Hexachlorophene	G, None	SW-846, #8270	10
Naphthalene			10
Phenol			10
Kerosene			10 ppm
Hexachlorobenzene			10
Pentachlorobenzene			10
1,2-dichlorobenzene			10
1,3-dichlorobenzene			10
1,4-dichlorobenzene			10
1,2,3-trichlorobenzene			10
1,3,5-trichlorobenzene			10
1,2,3,4-tetrachlorobenzene			10
1,2,3,5-tetrachlorobenzene			10
1,2,4,5-tetrachlorobenzene			10
Additional semi-volatiles			10
Ethylene glycol	G, None	GC/FID[g,h]	10 ppm

[a]P = plastic, G = glass.
[b]All samples cooled to 4°C upon collection.
[c]Constituents grouped together within brackets are anlyzed by the same method.
[d]Detection limit units except where indicated.
[e]In-house analytical method (PNL).
[f]IC = ion chromatography.
[g]DAI = direct aqueous injection.
[h]GC/FID = gas chromatography/flame ionization detector.

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screening limit for Interim Primary DWS. Gross alpha and uranium are closely correlated (Schalla et al. 1988b). However, subtraction of uranium from gross alpha would probably bring gross alpha to below the "adjusted " gross alpha limit (15 pCi/L). Chromium, mercury, selenium, and fluoride were reported as being above Interim Primary DWS at least once.

3.3.4 Recent Resource Conservation and Recovery Act of 1976 Groundwater Monitoring

In 1986 and 1987, 18 new wells (Figure 3-11) were installed to enhance the understanding of hydrogeology at the 300 APT and to help characterize the direction and extent of contamination in Hanford and Ringold Formation sediments. The new wells, which were designed to meet WAC 173-160 standards, included three well clusters (399-1-16ABC, 399-1-17ABC, and 399-1-18ABC) and eight single wells. Each well cluster included one well in the upper portion of the unconfined aquifer ("A" well), one well at the bottom of the unconfined aquifer ("B" well), and one well in the uppermost confined aquifer below the Ringold Formation lower mud unit ("C" well). Total number of wells in the network temporarily rose to 34 (16 original plus 18 new wells). The samples from the network of 34 monitoring wells were analyzed for a list of constituents, which included the list of dangerous waste constituents in WAC 173-303-9905 (PNL 1988). Later some wells were dropped because they did not meet WAC 173-160 standards. However, other wells (e.g., 399-2-1 and 399-3-10) were added even though they did not meet WAC 173-160 standards. They were added because they were in good positions to intercept contaminants flowing southeast from the 300 APT that had passed wells closer to the trenches. Wells added that did not conform to WAC 173-160 standards provided data for information and supplementary purposes only. Important RCRA unit decisions could not be made based on data from wells that did not meet the WAC 173-160 standards.

Since 1989, wells were periodically dropped from the network and the sampling schedule was changed from monthly to quarterly and eventually to semiannually. These changes were made because data quality objectives (DQO) in the groundwater monitoring plan (Schalla et al. 1988a) regarding hydrogeology and contamination were satisfied, the ERA in 1991 significantly reduced contamination in the trenches, and fewer wells sampled less frequently would still provide adequate groundwater monitoring. Currently the well network has been reduced to 11 wells sampled semiannually (Figure 3-12). Table 3-5 lists the 11 wells, the aquifers screened, sampling frequency, frequency of water level measurements, and compliance with WAC 173-160 standards. Table 3-7 lists the contaminant constituents analyzed in the current monitoring well network and the frequency of the sampling. One well (399-1-17A) is still sampled quarterly in order to comply with regulatory requirements for quarterly sampling for sites under groundwater quality assessment programs and to provide a rapid detection or early warning for any new contaminants inadvertently discharged to the 300 APT prior to January 1995 when lines to the trenches were "blanked" off.

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Figure 3-11. Locations of Monitoring Wells Added to the Network in 1986 and 1987.

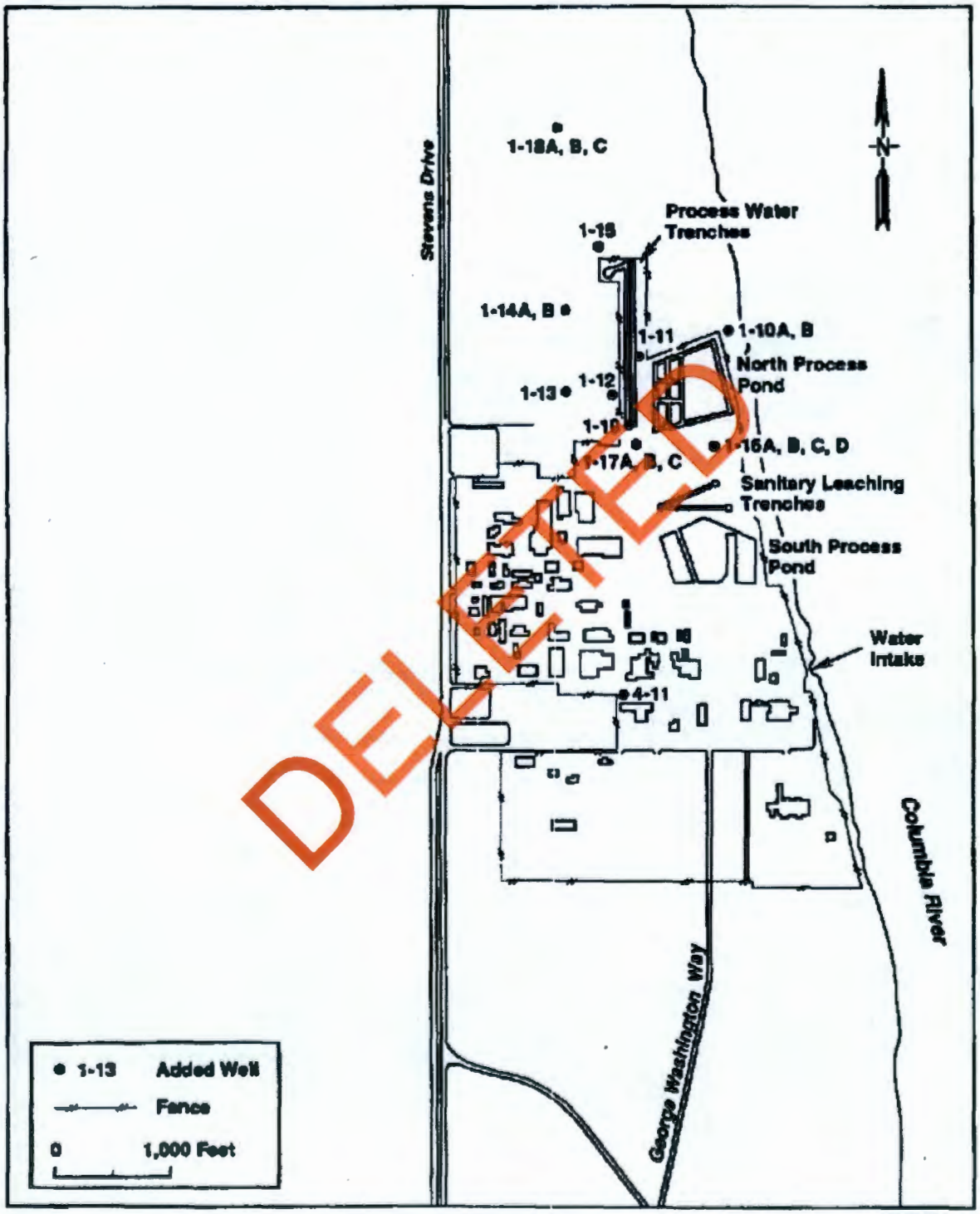

Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Acenaphthalene	8270
Acenaphthylene	8270
Acetone	8240
Allyl chloride	8240
Aniline	8270
Anthracene	8270
Antimony	6010
Aramite	8270
Benzo[k]fluoranthene	8270
Benzo[ghi]perylene	8270
Benzyl alcohol	8270
alpha-BHC	8080
beta-BHC	8080
delta-BHC	8080
gamma-BHC; Lindane	8080
Bis(2-chloro-1-methyl-ethyl) ether; 2,2'-Dichlorodiisopropyl ether	8270
Bromodichloromethane	8240
4-Chlorophenyl phenyl	8270
Chloroprene	8240
Cobalt	6010
Copper	6010
Dibenzofuran	8270
Dibromochloromethane; Chlorodibromomethane	8240
1,2-Dibromo-3-chloro-propane; DBCP	8240
p-(Dimethylamino) azobenzene	8270
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	8270
Ethylbenzene	8240

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Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Fluorene	8270
Isodrin	8270
Isophorone	8270
Methoxychlor	8270
Methylene bromide; Dibromomethane	8240
Methylene chloride; Dichloromethane	8240
2-Methylnaphthalene	8270
4-Methyl-2-pentanone; Methyl isobutyl ketone	8240
o-Nitroaniline	8270
m-Nitroaniline	8270
Nitrobenzene	8270
p-Nitrophenol	8270
N-Nitrosodiphenylamine	8270
N-Nitrosodipropylamine; Di-n-propylnitrosamine	8270
Phenanthrene	8270
Pyrene	8270
Safrole	8270
Styrene	8240
Sulfide	9030
Tin	6010
Vanadium	6010

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Table 3-6. Appendix IX Constituents Not in WAC 173-303-9905 List.* (3 sheets)

Appendix IX Constituent	SW-846 Method*
Vinyl acetate	8240
Xylene	8240
Zinc	6010

*Constituents listed here were analyzed in all 11 wells of the 300 APT (Figure 3-12) by the methods listed.

*SW-846 Methods.

6010 - ICP Metals (see Table 4-1, this document).

8240 - Volatile Organic Analysis (Gas Chromatograph since 1994, Gas Chromatograph/Mass Spectrometer before 1994 - See Table 4-4, this document).

8270 - Semi-Volatile Organic Analysis (Analyzed in all eleven 300 APT wells during the period 5/88-5/90).

8080 - Pesticides (see Table 4-1, this document).

9030 - Sulfide (Analyzed in all 11 300 APT wells 2/87-5/90).

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Table 3-7. Constituents Analyzed in the Current Monitoring Well Network.

Semiannual Schedule - All 11 300 APT Network Wells

Alkalinity
Gross Alpha
Gross Beta
Uranium
Coliform
Specific Conductance (Lab)
ICP Metals (including arsenic, selenium, and lead) - unfiltered
ICP Metals (including arsenic, selenium, and lead) - filtered
Mercury - unfiltered
Mercury - filtered
pH (Lab)
Radium
TOC
TOX
Tritium
Volatile Organics Analysis (GC)

Quarterly Schedule - Well 1-17C Only

Anions
Specific Conductance (Lab)
Gamma Scan
pH (Lab)
Strontium-90
TOX
TOC
Isotopic Uranium
Uranium
Volatile Organics Analysis (GC)

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Results of groundwater sampling and analysis since Schalla et al. (1988a; 1988b) are reported quarterly (data only) and annually (including interpretations) as RCRA reports by the Westinghouse Hanford Company (WHC) Groundwater Management Group for the U.S. Department of Energy (DOE). The following is a summary of results since 1987.

Only chromium, lead, selenium, lindane, and gross alpha have values larger than the maximum contaminant levels (MCLs). Chromium exceedances (Appendix C) may be the result of an excessive amount of suspended particles (turbidity) in groundwater samples because the exceedances are associated with unfiltered samples. Lead exceedances occurred prior to the ERA (1991) in two wells that did not meet WAC 173-160 standards for construction. Since the ERA, lead concentrations have been below the MCL of 50 μg/L. Exceedances of selenium and lindane may actually be analytical problems due to detection limits that are higher than respective MCLs. Other constituents of interest such as gamma-emitting radionuclides and strontium-90, copper, sulfate, zinc, chloride, and silver were all below the Primary and Secondary DWS or the 4 mrem/yr equivalent concentration for radionuclides (Appendix C). (Gross alpha and uranium are discussed later).

Volatile Organic Analysis (VOAs) results indicate that several constituents are detected in downgradient wells of the 300 APT well network. The detected VOA constituents include PCE, toluene, xylene, benzene, TCE, chloroform, ethylbenzene, and cis-DCE (Appendix C). However, only TCE and cis-DCE are consistently above the DWS of 5 and 70 μg/L, respectively. The well showing the exceedances of TCE and cis-DCE is 399-1-16B, which is a downgradient well screened at the bottom of the unconfined aquifer (Figures 3-13 and 3-14).

Concentrations of iron and manganese in filtered samples are consistently higher than DWS for two wells, iron in well 399-1-17B and manganese in well 399-1-16B and 399-1-17B (Appendix C). Both wells are screened at the bottom of the unconfined aquifer. These results may be due to reducing conditions and the effect on well structures such as stainless steel casing and the effects of drilling. A similar relationship between sampling depth and concentration profiles for redox-sensitive species has been documented in Johnson et al. (1994).

Uranium continues to be detected in several wells in the vicinity of the 300 APT and is correlated with gross alpha (Schalla et al. 1988b, Section 7.2; Appendix C; Figure 3-15). The 1991 ERA reduced the concentrations of gross alpha and uranium (Appendix C) significantly in wells downgradient of the 300 APT. Currently, uranium concentrations at wells 399-1-17A and 399-1-10A are above the EPA (proposed) guidance value of 20 μg/L for total uranium (EPA 1991). The MCL for gross alpha is based on the exclusion of the uranium component, which is referred to as "adjusted" gross alpha. In a few cases, the adjusted gross alpha concentrations have exceeded the 15 pCi/L (adjusted) gross alpha standard (EPA 1991; 40 CFR 141.15). However, on the average, the standard is not exceeded in any of the downgradient wells. The occasional exceedances of the adjusted gross alpha standard are attributed to random fluctuations in the measurement of gross alpha and uranium, and/or perhaps due to the presence of some residual radon decay products. Specific isotopic analyses (e.g., plutonium-238, 239, 240 and americium-241) would be needed to

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Figure 3-13. Trichloroethene Plume.

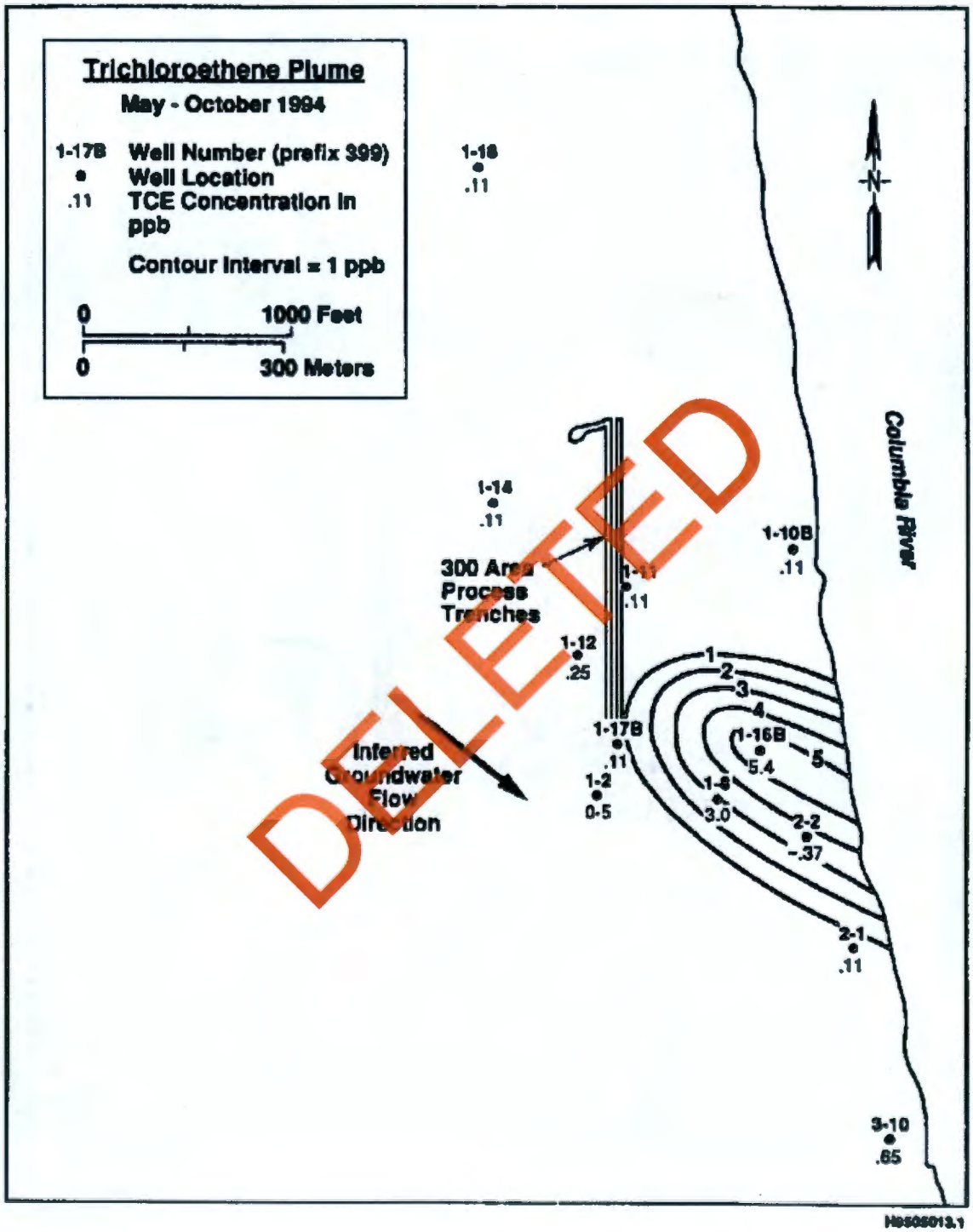


Figure 3-14. CIS 1,2-Dichloroethene Plume.

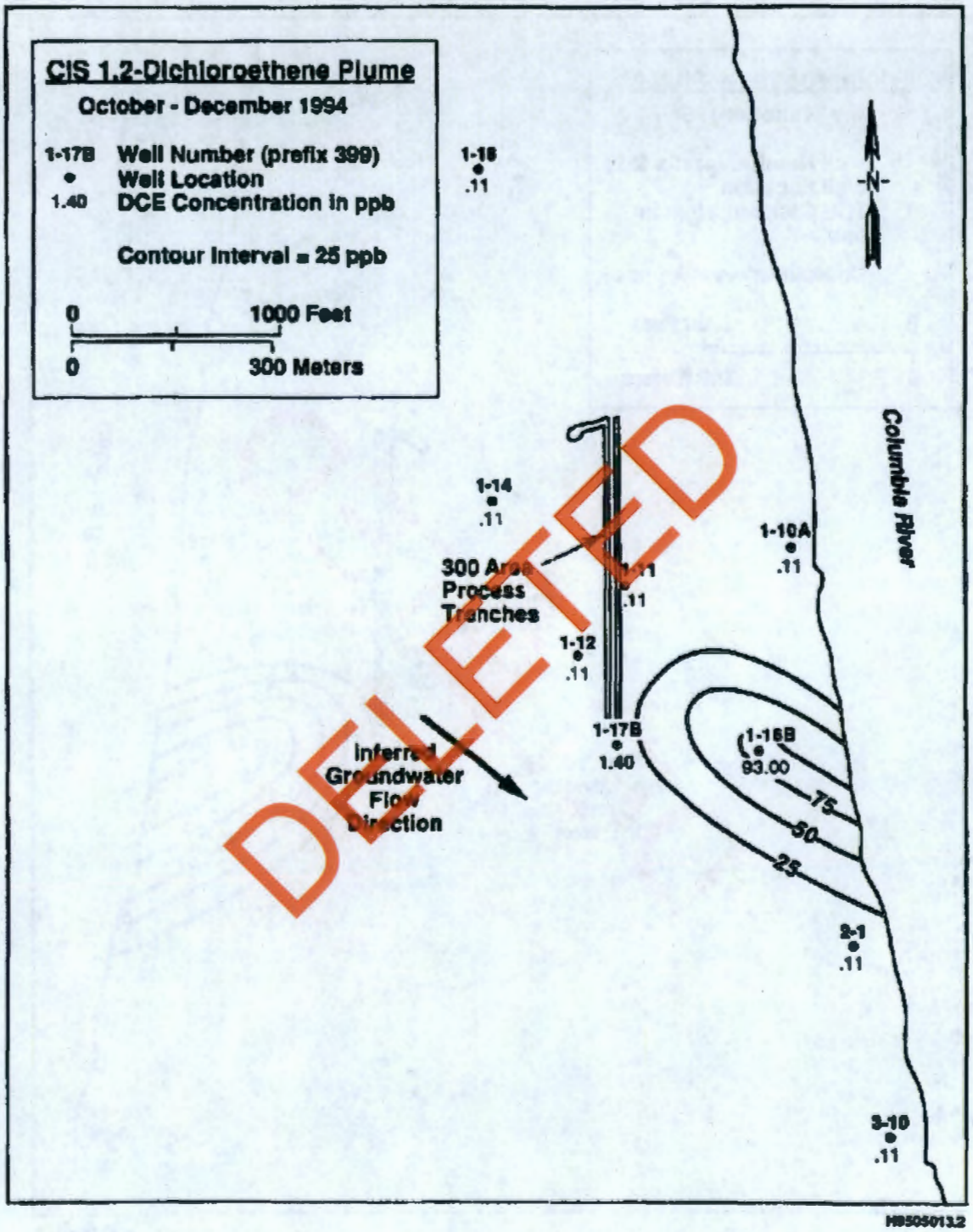
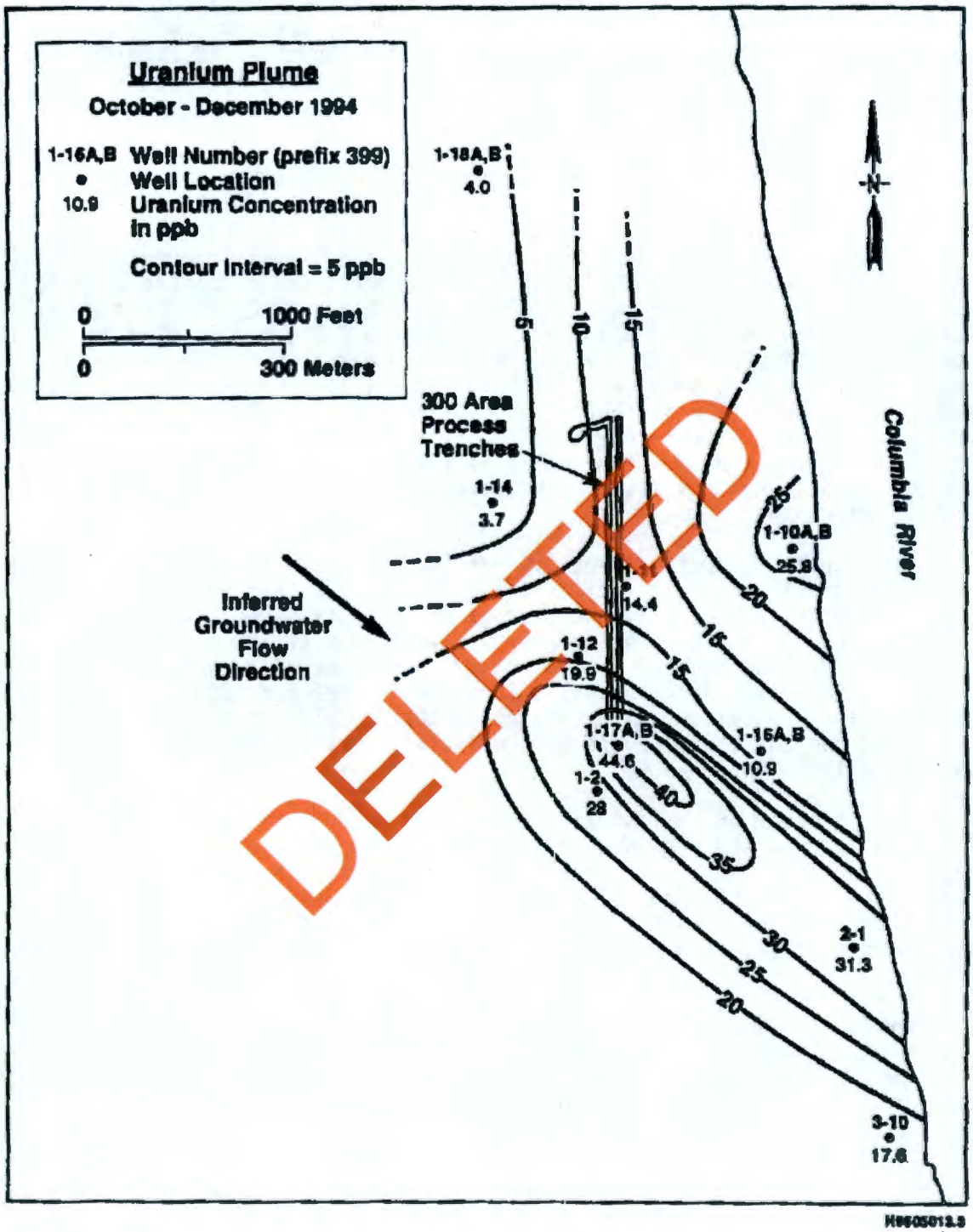


Figure 3-15. Uranium Plume.



rule out the presence of other alpha emitters in groundwater at this site since they have not been previously excluded on the basis of direct measurements in groundwater at the 300 APT. However, based on soil column analytical results (DOE-RL 1995a, Appendix 7D) and the expected chemical behavior of plutonium and americium, it is highly unlikely that transuranics are present in groundwater beneath the 300 APT.

3.4 CONCEPTUAL MODEL FOR LOCALIZED "DEEP" AQUIFER OCCURRENCE OF CHLORINATED HYDROCARBONS

A conceptual model is needed to explain the persistent occurrence of TCE and related degradation products in one downgradient well completed at the bottom of the unconfined aquifer (-16B) (Figures 3-13 and 3-14). One possible explanation is that a liquid phase of PCE (density 1.6 g/ml) settled to the bottom of the aquifer beneath the 300 APT. Slow dissolution and microbial degradation of the free phase would then provide a long-term source of PCE and degradation products (TCE and DCE) to the deeper zone of the unconfined aquifer. Since well -16B is downgradient from the trenches, this well would be in the contaminant plume from such a source. If this explanation is correct, it should be consistent with the hydrogeology and hydraulic setting previously discussed.

For example, the Darcy velocity, see Equation (1), is 0.0016 m/d using an average hydraulic conductivity of 1.4 m/d for the bottom of the unconfined aquifer at 300 APT (Table 3-2), an average gradient of 0.00035, and an effective porosity of 0.3. The observation well is over 300 m (984 ft) downgradient from the trench, suggesting a travel time of greater than 500 years. Since the recorded spills occurred in 1982 and 1984, the computed travel time is inconsistent with this conceptual model. It is also noteworthy that PCE and degradation products were detected shortly after well -16B was installed in 1987 (Appendix C).

Thus, it seems unlikely that the observed chlorinated hydrocarbons in -16B are related to the recorded spills in 1982 and 1984. One alternative possibility is that, during the early years of operations, undocumented ground disposal occurred in the upgradient vicinity of the well. Since this is currently the only well with a persistent occurrence of significant concentrations of chlorinated hydrocarbons, a local source near the well is suggested.

Additional field work would be needed to investigate the possibility of soil dump sites near well -16B and or to distinguish among other possible alternatives. These possibilities should be considered if the groundwater MCL exceedances for TCE and related degradation products persist.

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4.0 GROUNDWATER MONITORING PROGRAM

Chapter 4.0 describes the groundwater monitoring activities to be conducted at the 300 APT during the compliance period (including the closure period) for this unit. The groundwater monitoring program is designed to (1) protect human health and the environment; (2) comply with the intent of final status groundwater monitoring requirements of WAC 173-303-645 (Ecology 1986) and 40 CFR 264 Subpart F; and (3) conduct groundwater investigations or remediation, should it become necessary, in a technically sound and cost effective manner.

Three levels of groundwater monitoring programs are identified under final status regulations: (1) detection monitoring, (2) compliance monitoring, and (3) corrective action (Figure 4-1). Each monitoring program is briefly described below.

Detection level monitoring program. Indicator parameter data (e.g., pH, specific conductance, TOC, TOX, or heavy metals, waste constituents, or reaction products) from downgradient compliance point wells are compared with background wells data semiannually to determine if the unit is impacting the groundwater quality.

Compliance level monitoring program. If groundwater sampling during the detection level monitoring program reveals a statistically significant increase (or pH decrease) over upgradient background concentrations for groundwater, a compliance level monitoring program is established. The monitoring objective is to determine whether groundwater concentration limits have been exceeded at the downgradient (compliance) wells.

Corrective action level monitoring program. If the referenced concentration limit(s) for a given groundwater parameter or parameters are significantly exceeded during compliance monitoring, a corrective action level monitoring program will be developed and implemented to protect human health and the environment.

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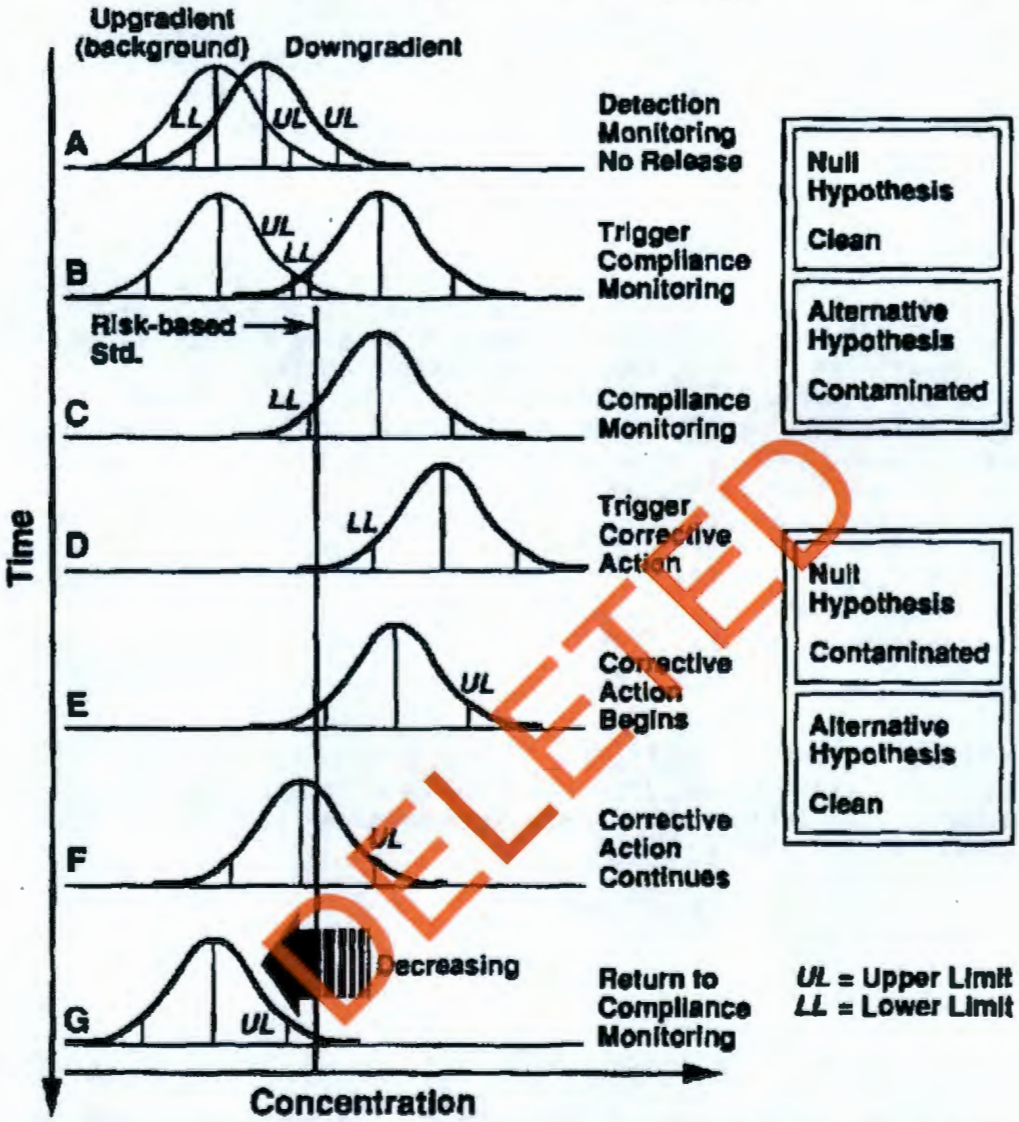
4.1 OBJECTIVES OF GROUNDWATER MONITORING PROGRAM

The 300 APT groundwater monitoring program bypassed the detection-level stage and went directly into a RCRA interim-status (assessment) level program in June 1985. The detection-level monitoring program was bypassed because groundwater was already known to be contaminated. Monitoring wells were constructed in response to a Consent Agreement and Compliance Order issued jointly by Ecology and the EPA (Ecology and EPA 1986).

The 300 APT is scheduled to be included the final-status RCRA Permit as a TSD unit undergoing closure through the permit modification process in September 1995. The groundwater near the 300 APT needs to be monitored under a final status program that is comparable or equivalent to the assessment level initiated under the interim status. Hence, a compliance monitoring program is proposed for the 300 APT. The proposed compliance monitoring program will (1) obtain samples that are representative of existing groundwater conditions; (2) identity key monitoring constituents that are

Figure 4-1. A Statistical Perspective of the Sequence of Groundwater Monitoring Requirements Under the Resource Conservation



(Notice that until contamination above a risk standard is documented (D) the null hypothesis is that the facility is clean. Once the facility has been proven to be in exceedance of a health criteria then the null hypothesis is that the facility is contaminated until proven otherwise (G).

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attributable to past operations of the 300 APT; (3) determine applicable groundwater concentration limits (e.g., risk-based maximum concentration limits); and (4) determine whether referenced groundwater concentration limit(s) for a given parameter or parameters are exceeded. A DQO process is used to guide the groundwater monitoring activities to be conducted for the 300 APT. The primary purpose of the DQO process is to ensure that the type, quantity, and quality of groundwater monitoring data used in the decision-making process are appropriate for their intended applications. Details concerning the DQO process can be found in EPA (1993).

4.2 DANGEROUS WASTE CONSTITUENTS

Section 4.2 identifies constituents that are attributable to past operations of the 300 APT. Groundwater chemistry samples are collected quarterly from well 399-1-17A to provide near-trench monitoring of contaminants. All other wells in the monitoring network are sampled semiannually. Monitoring results have been reported in the RCRA quarterly and annual reports. Since 1987, a very large amount of hydrogeologic and contaminant data have been collected from the 300 APT wells. Consequently, the rate, extent, and concentrations of groundwater contaminants originating from the 300 APT are well understood (WHC 1990). Furthermore, an ERA was initiated in July 1991. The ERA removed a layer of contaminated sediments containing uranium, copper, chromium, and silver. In January 1995, the 300 APT was permanently isolated from the process sewer (its only source of effluent), therefore eliminating the trenches as a source of groundwater recharge.

Groundwater monitoring results are available from the Hanford Environmental Information System (HEIS) and the Geosciences Data Analysis ToolKit (GeoDAT). The following are considered when deriving a constituent list appropriate for the 300 APT:

- Inventory/process knowledge
- Driving force
- Contaminant mobility
- Preferential pathways
- Monitoring objectives
- Detection history at the unit.

Per WAC 173-303-645 and 40 CFR 264, Subpart F, groundwater concentration limits must be established in the facility permit (by the regulators). These limits are not to be exceeded. These concentration limits may be different than the risk-based groundwater cleanup standards as required by the Method C (industrial scenario) of the Model Toxics Control Act, WAC 173-340-720(4). Table 4-1 summarizes the status of 14 constituents where groundwater concentration limits have been established (see WAC 173-303-645(5)(a), Table 1).

Only chromium, lead, selenium, and lindane have values larger than the MCLs given in WAC 173-303-645(5)(a), Table 1. Chromium exceedances were isolated events that were probably caused by suspended particulate in the unfiltered samples. Lead exceedances were observed, prior to the 1991 ERA, in two non-RCRA wells. After the ERA, lead concentrations have been below the

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Table 4-1. Status of Monitoring Results for Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Arsenic	0.05	50	N	<0.64 - 6.7 (unfiltered) <0.64 - 6.2 (filtered)
Barium	1.0	1,000	N	<2.0 - 70 (unfiltered) <2.0 - 70 (filtered)
Cadmium	0.01[c]	10[c]	Y[d]	<10 (unfiltered) <10 (filtered)
Chromium	0.05[c]	50[c]	Y	4 occurrences observed in unfiltered samples from wells 3-1-12 (150 ppb), 3-1-16A (147 ppb), 3-1-17A (140 ppb), 3-1-18A (120 ppb).
Lead	0.05	50	Y	2 occurrences (in 1985) observed in unfiltered samples from non-RCRA standards wells 3-2-1 (55 and 58 ppb) and 3-3-10 (77.5 and 73.5 ppb).
Mercury	0.002	2	N	<0.2 (unfiltered) <0.2 (filtered)
Selenium	0.01	10	Y[d]	<20 (unfiltered) <10 (filtered)
Silver	0.05	50	N	<20 (unfiltered) <20 (filtered)
Endrin	0.0002	0.2	Y[d]	<1 (all samples)
Lindane	0.004	4	N	<0.05 (all samples)
Methoxychlor	0.1	100	N	<2 (all samples)
Toxaphene	0.005	5	N	<2 (all samples)
2,4-D	0.1	100	N	<10 (all samples)
2,4,5-TP silvex	0.01	10	N	<2 (all samples)

MCL = maximum contaminant level. Y/N = yes/no.
[a]from WAC 173-303-645 (5)(a).
[b]from results analyzed by DataChem Laboratories (after 12/31/91).
[c]MCLs for chromium and cadmium have been revised to 0.1 mg/L (100 μg/L) and to 0.005 mg/L (5 μg/L), respectively, per 40 CFR 141.62 (b)(5), effective 7/30/92.
[d]all samples were essentially not detected (exceedances due to detection limits larger than required MCLs).

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MCL of 50 μg/L. All samples analyzed for cadmium, selenium, and lindane were essentially non-detects and the exceedances were caused by detection limits that were higher than the respective MCLs. Other constituents of interest (e.g., copper, sulfate, zinc, chloride, silver, gamma-emitting radionuclides, and strontium-90) were all below the Primary and Secondary DWS or the 4 mrem/yr equivalent concentrations for radionuclides (see Tables 4-2 and 4-3). Gross alpha and uranium exceedances were observed in all wells in the monitoring network except for wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A. Gross beta exceedances were observed in wells 3-1-10A, 3-1-11, and 3-1-16A. In general, the excess beta can be accounted for by the beta decays associated with the uranium-238 present in the groundwater samples from the 300 APT wells that exhibit gross beta levels >50 pCi/L.

An evaluation of VOA results revealed that detected analytes include PCE, toluene, xylene, benzene, TCE, chloroform, ethylbenzene, and cis-DCE (see Table 4-4). Only TCE and DCE have been observed in well 3-1-16B consistently above the DWS of 5 and 70 μg/L, respectively. Unplanned releases (two spills) of PCE occurred in 1982 and 1984.

Concentrations of iron and manganese in filtered samples are consistently higher than the respective DWS in two wells (3-1-17B for iron, 3-1-16B and 3-1-17B for manganese) of the 300 APT network (see Table 4-3). These two wells were completed at the bottom of the unconfined aquifer. The elevated iron and manganese concentrations observed in the "deep" unconfined aquifer are probably influenced by chemical reducing conditions (i.e., the absence of oxygen and negative oxidation-reduction potentials). A similar relationship between sampling depth and concentration profiles for redox sensitive species has been documented in WHC (Johnson et al. 1994). A limited follow-up geochemical investigation is needed. Measurements of Eh (redox potential) and dissolved oxygen should be determined for these two wells to confirm that the hypothesized reducing conditions exist at these wells. Metals (iron and manganese) will be added to the list of monitoring constituents if it can be demonstrated that the elevated concentrations are caused by other than chemical reducing conditions.

Uranium was the most significant and widespread groundwater contaminant resulting from past operations of the 300 APT. The mitigating action of the ERA reduced uranium concentrations in well 3-1-17A significantly. Currently, uranium concentrations at wells 3-1-17A and 3-1-10A have remained above the EPA <u>proposed</u> guidance value of 20 μg/L for total uranium (EPA 1991). However, the EPA proposed standard of 20 μg/L applies to community and nontransient, noncommunity water systems. This may be ultra conservative for the 300 APT.

Based on the above considerations, the following constituents are proposed for the initial monitoring program to comply with WAC 173-303-645(4). The list will be reassessed periodically and revised should there be a need to update the monitoring list.

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Table 4-2. Status of Monitoring Results for Other Hazardous Chemical Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (µg/L)	Exceed (Y/N)	Concentration Range[b] (µg/L)
Copper	1.0	1,000	N	<2.0 - 20.0 (unfiltered) <2.6 - 20.0 (filtered)
Iron	0.3	300	Y	3-1-17B (320 - 450), in filtered samples
Manganese	0.05	50	Y	3-1-16B (67 - 74), in filtered samples 3-1-17B (67 - 83), in filtered samples
Sulfate	250	250,000	N	(11,000 - 53,000)
Total Dissolved Solids (TDS)	500	500,000	N	(221,000 - 248,000), TDS data in well 3-1-10A only
Zinc	5	5,000	N	<3.44 - 24.0 (unfiltered) <3.44 - 23.0 (filtered)
Chloride	250	250,000	N	(4,600 - 150,000)

MCL = maximum contaminant level. Y/N = yes/no.
[a]from 40 CFR 143.3 Secondary Maximum Contaminant Levels.
[b]from results analyzed by Datachem Laboratories (after 12/31/91).

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Table 4-3. Status of Monitoring Results for Radiological Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent	MCL (pCi/L)	MCL (μg/L)	Exceed (Y/N)	Concentration Range[b] (μg/L)
Gross Alpha	15		Y	exceedance observed in all wells except for in wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A
Uranium		20[a]	Y	exceedance observed in all wells except for in wells 3-1-14A, 3-1-16B, 3-1-17B, and 3-1-18A
Gross Beta	50		Y	exceedance observed in wells 3-1-10A (13.6 - 68), 3-1-11 (6.51 - 63), and 3-1-16A (20 - 88)
Sr-90	8		N	essentially all ND
Tc-99	900		N	(10 - 281) in 3-1-10A, where the upper value 281 was flagged with a "R" (rejected) for gross α and gross β analyses
Tritium	20,000		N	highest range of concentrations were observed in well 3-1-18A, (10,900 - 11,500) indicating upgradient source of contamination
Cs-137	200		N	essentially all ND
Co-60	100		N	essentially all ND

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MCL = maximum contaminant level.
Y/N = yes/no.
[a]From Federal Register, Vol. 56, No. 138, 7/18/1991, Proposed Rule: National Primary Drinking Water Regulations, Radionuclides (EPA 1991).
[b]From results analyzed by DataChem Laboratories (after 12/31/91).

Table 4-4. Status of Monitoring Results for Detected VOA Constituents in the 300 Area Process Trenches for Groundwater Protection.

Constituent[a]	MCL (mg/L)	MCL (µg/L)	Exceed (Y/N)	Concentration Range[b] (µg/L)
Ethylbenzene	0.7	700	N	0.06 - 0.08
Toluene	1	1,000	N	0.03 - 0.06
Tetrachloroethylene	0.005	5	N	0.09 - 0.74
Xylenes	10	10,000	N	0.05 - 0.08
Cis-1,2-DCE	0.070	70	Y	exceedance observed in well 3-1-16B[c]
Chloroform	None	None	NA	0.06 - 9.30 (GC) 1.40 - 22.0 (GC/MS)
Benzene	0.005	5	N	0.02 - 0.06
TCE	0.005	5	Y	exceedance observed in well 3-1-16B[c]

MCL = maximum contaminant level.
Y/N = yes/no.
NA = not applicable.
[a]VOA analyzed by Gas Chromatography (GC) and/or Gas Chromatography/Mass Spectrometry (GC/MS).
[b]From results analyzed by DataChem Laboratories (after 12/31/91).
[c]See time vs concentration plots in Appendix C.

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- Radionuclides--chemical uranium
- VOAs--TCE and DCE
- Metals--iron and manganese will be added to the list depending on the outcome of follow-up geochemical investigations (i.e., if elevated levels are not due to chemical reducing conditions.

Additional constituents will be collected (see Section 4.5.1).

4.3 GROUNDWATER MONITORING WELLS

The proposed groundwater monitoring network for the 300 APT contains eight wells set up as four pairs of deep and shallow wells for the unconfined aquifer (Table 4-5). Three of the well pairs are downgradient and one pair is upgradient (Figure 4-2). The wells were selected in order to fulfill the requirements for monitoring well networks for RCRA sites in compliance programs of final status (WAC 173-303-645). Appendix A contains the well construction and completion summaries, including schematics, for the eight wells. Specifically, the objective was to select wells that would monitor the appropriate portion of the aquifer for waste constituents of concern. In the case of the 300 APT the constituents of concern are TCE, DCE, uranium, and possibly iron and manganese (see Section 4.2). All but TCE and DCE are migrating through the upper portions of the unconfined aquifer. TCE and cis-DCE are detected in wells monitoring the base of the unconfined aquifer (see Section 3.4). Therefore, wells screened in the bottom portion of the aquifer are appropriate too, both down- and up-gradient. The three downgradient well pairs (399-1-10AB, 399-1-16AB, and 399-1-17AB) are east, southeast, and south, respectively, of the 300 APT to intercept any groundwater contaminants emanating from the 300 APT and flowing with the groundwater in directions consistent with historical data. Based on the Monitoring Efficiency Model (Jackson et al. 1991), the proposed downgradient wells should provide a monitoring efficiency of approximately 88%, assuming a groundwater flow direction of south-southeast (S.27°E or 153° azimuth). The upgradient well pair (399-1-18AB) was chosen because it was close to the 300 APT but not too close to the trenches to encounter contaminants temporarily flowing in a reverse direction when the Columbia River stage is high. All eight of the proposed wells were constructed to WAC 173-160 standards.

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4.4 COMPLIANCE MONITORING

Groundwater protection regulations establish requirements concerning groundwater monitoring and corrective action standards for the permitted regulated units (e.g., surface impoundment, land disposal unit). Furthermore, for each dangerous waste constituent entering the groundwater from a regulated unit, the unit permit must include a concentration limit that cannot be exceeded. These concentration limits are the "triggers" that determine the need for further action.

Table 4-5. Proposed Wells for the 300 Area Process Trenches Monitoring Well Network.

Well	Aquifer	Sampling Frequency	Water Levels	Well Standards
399-1-10A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-10B[91]	Bottom Unconfined	Semiannual	Quarterly	WAC-173-160
399-1-16A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-16B[87]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-17A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-17B[86]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-18A[86]	Top Unconfined	Semiannual	Quarterly	WAC 173-160
399-1-18B[87]	Bottom Unconfined	Semiannual	Quarterly	WAC 173-160

Note: Superscript following well number denotes the year of construction.

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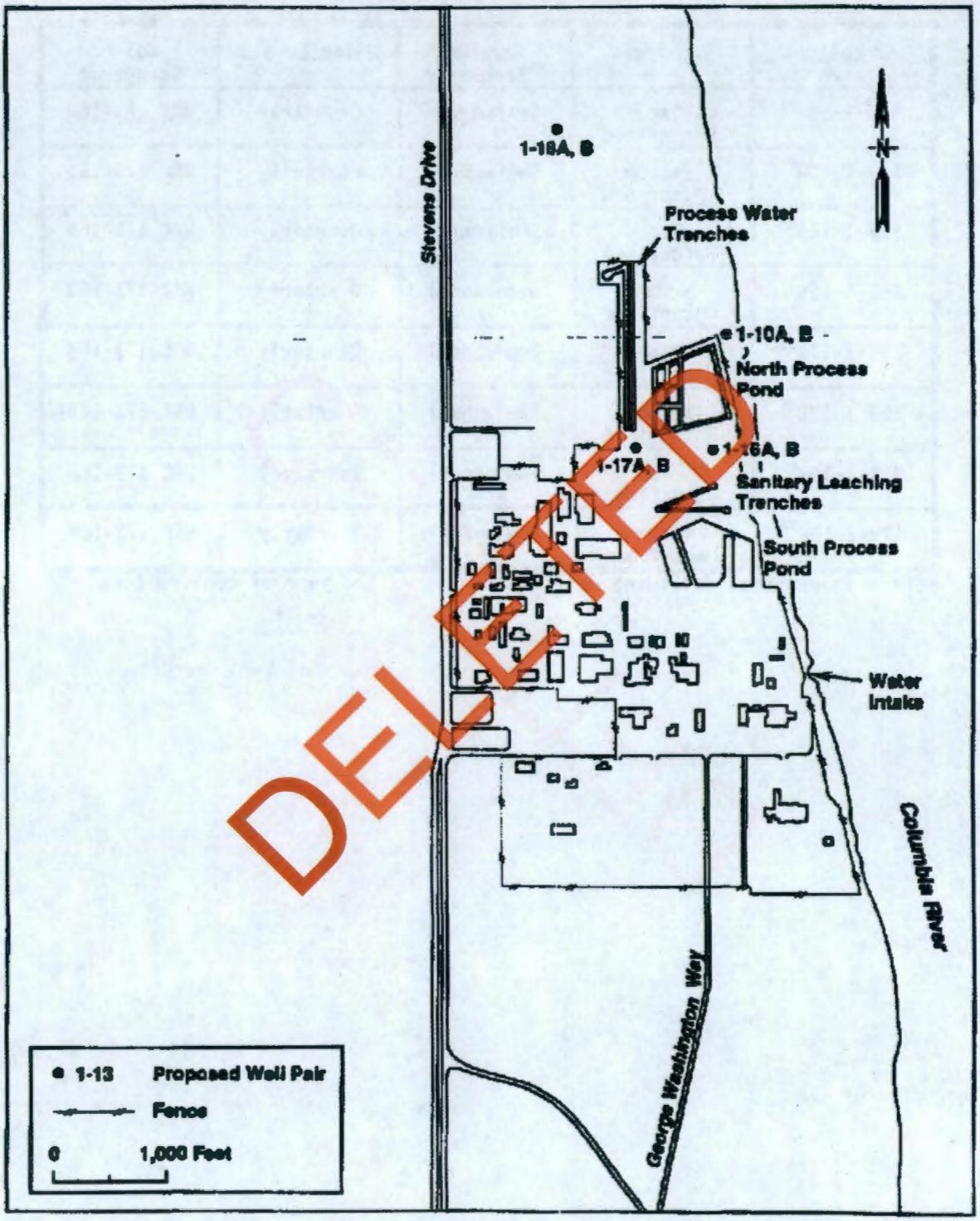
Figure 4-2. Locations of Monitoring Wells Proposed for the Revised 300 Area Process Trenches Groundwater Monitoring Plan.



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4.4.1 Concentration Limits

For the 300 APT constituents of concern, the proposal is to use the following MCLs as the concentration limits.

1. For TCE, the MCL is 5 μg/L. This limit is based on National Primary DWS (40 CFR 141.61(a)). This limit is also the MCL set forth in WAC 246-290-310.

2. For cis-DCE, the MCL is 70 μg/L. This limit is based on National Primary DWS (40 CFR 141.61(a)).

3. For uranium, there is no DWS established. However, 20 μg/L for total uranium in public drinking water supplies was included in proposed changes to 40 CFR 141 (EPA 1991). This value is proposed for the 300 APT until the rule containing the subject standard is promulgated.

Groundwater quality criteria for TCE is set at a different level, 3 μg/L, in WAC 173-303-200. However, the purpose of WAC 173-303-200 is to set groundwater quality standards that are (1) preventative in nature and (2) protective of existing and future beneficial uses through the reduction or elimination of contaminants discharged to the subsurface. Therefore, these standards are more stringent than other types of standards in order to control the source discharged to groundwater. Once contaminants have reached groundwater, the applicable standard should be set at the MCL and/or the state required cleanup standard.

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4.4.2 Point of Compliance

The point of compliance (POC) is defined in 40 CFR 264.95 and WAC 173-303-645(6) as a "vertical surface" located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated unit. The POC is the place in the uppermost aquifer where groundwater monitoring takes place and the groundwater protection standard is set. For the 300 APT, the POC should be the downgradient monitoring wells as provided in Section 4.3. (i.e., monitoring wells 3-1-10A and -10B, 3-1-16A and -16B, 3-1-17A and -17B).

4.4.3 Compliance Period

The compliance period is defined as the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period). Typically, groundwater monitoring is required for a period of 30 years following completion of closure activities, although this time frame may be shortened or extended by the regulatory authority. If corrective action is engaged by the owner or operator (due to exceedance of groundwater concentration limit), then the compliance period will be extended until it can be demonstrated that the applicable limit has not been exceeded for a period of three consecutive years.

4.5 SAMPLING AND ANALYSIS

Section 4.5 describes or references procedures for sample collection, sample preservation and shipment, chain of custody requirements, analytical procedures, and quality assurance. Specific sampling and analysis procedures are referenced. Work by subcontractors shall be conducted to their equivalent approved standard operating procedures.

All field sampling activities will be recorded in the proper field logbook as specified in EII 1.5 and subsequent revisions (WHC 1988). Electric submersible or Hydrostar[3] pumps will continue to be used in existing monitoring wells for purging and sampling. Before sampling each well, the static water level will be measured and recorded as specified in EII 10.2 (WHC 1988). Based on the measured water level and well construction details, the volume of water in the well will be calculated and documented in the well sampling form or field notebook. These steps will be performed electronically in the field. As specified in EII 5.8, each well will be purged before sampling until the approved criteria are met (WHC 1988). Purge water will managed according to EII 10.3 (WHC 1988). In the situations where the well pumps dry because of very slow recharge, the sample will be collected after recharge. Samples will be collected and field preserved as specified in EII 5.8. Sampling equipment decontamination will follow procedures specified in EII 5.4 (WHC 1988).

Sample chain-of-custody, sample packaging, and shipping required by WAC 173-303-645(8)(d) are discussed in EII 5.1 and 5.11 (WHC 1988). The general quality assurance/control (QA/QC) protocols will include the site-specific analytes for this plan (WHC 1993). The purpose of the QC activities is to determine and documente that samples were carefully collected and transferred to an analytical laboratory, that the quality of the analytical results being produced by the laboratory are defensible, and that corrective actions will be taken as necessary.

Under the proposed compliance-level monitoring program, water-level elevation data will be evaluated annually to determine if the monitoring wells ae strategically located. If the evaluation indicates that existing wells are no longer adequately located, the groundwater monitoring network will be modified to bring it into compliance with WAC 173-303-645(8)(a). Descriptions of monitoring constituents, monitoring frequency, and analytical procedures specific to the 300 APT are provided below.

4.5.1 Constituents to be Analyzed

The constituents to be analyzed initially for the 300 APT include:

(1) <u>The detected constituents of concern identified in Section 4.2 (incuding uranium and biodegradation products of tetrachloroethylene).</u> These constituents of concern will be sampled independently four times in each sampling event (semiannually).

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[3]Hydrostar is a registered trademark of Instrumentation Northwest, Inc.

(2) Metals (iron and manganese). Groundwater samples will be analyzed semiannually for these metals together with dissolved oxygen and redox potential as part of the follow-up geochemical investigation (Section 4.2). They will be added to the constituents of concern list if elevated levels are not due to chemical reducing conditions.

(3) Four constituents required by Ecology including thallium, PCBs, chrysene, and benzo(a)pyrene. These four constituents are required by Ecology in response to their concern about dangerous wastes leaching from the relocated sediments stockpiled at the north ends of the trenches. Groundwater samples will be analyzed for these constituents semiannually for two years (four sampling periods). If the constituents are detected they will be added to the list of constituents of concern.

(4) Field parameters that are routinely measured at the well head (including pH, conductivity, turbidity, and temperature).

A large number of wells were sampled periodically during the 1988-1991 time period for dangerous waste constituents per WAC 173-303-9905 and site specific constituents (see Section 3.3). This effort established the constituents of concern for the interim remedial action and the final status monitoring plan. Since 300 APT discharges have ceased, only residual contaminants from past practice discharges should be present in groundwater in the vicinity of the trenches. Thus, previous groundwater characterization and monitoring data (historical data) are considered adequate for addressing the Appendix IX requirements for this final status monitoring plan.

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4.5.2 Background Values

Background values (area) are defined as the levels of chemical, physical, biological, or radiological constituents or parameters upgradient of a unit, practice, or activity that have not been affected by the unit. Groundwater monitoring data obtained from upgradient wells will be used to track the encroachment of upgradient sources of contaminant plumes. Background data also will be reevaluated if changes in groundwater flow directions result in changes in definition of upgradient wells.

4.5.3 Sample Frequency

In compliance with regulations, all wells (compliance and background) will be sampled at least semiannually during the compliance period. During each semiannual sampling event, a sequence of at least four independent samples will be collected from compliance wells and results compared to the groundwater concentration limits established in Section 4.4.1. Statistical methods are discussed in Section 4.6.

The requirement of obtaining four independent samples could be accomplished by reference to the uppermost aquifer's effective porosity (n_e); horizontal hydraulic conductivity (K_h); and hydraulic gradient (i). The

minimum time interval between sampling events that will provide an independent sample of groundwater is estimated as follows (EPA 1989):

1. Calculate the horizontal component of the average linear velocity of groundwater (V_h) using the Darcy equation

$$V_h = \frac{(K_h * i)}{n_e}$$

with:

K_h = 43 m/d (Swanson et al. 1992)

i = 0.0003 or 0.0004 (DOE-RL 1995b, Figures 6.1-4 and 6.1-5)

n_e = 0.2

V_h = (43 m/d * 0.0003)/0.2 = 0.0645 m/d, or

V_h = (43 m/d * 0.0004)/0.2 = 0.086 m/d

2. The horizontal component of the average linear velocity of groundwater, V_h, has been estimated to be from 0.0645 to 0.086 m/d. Monitoring well diameters at the 300 APT are 0.1016 m. Therefore, the minimum travel time, T, to obtain an independent sample for this unit is:

T = (0.1016 m)/(0.0645 m/d) = 1.6 d (based on i = 0.0003)

or

T = (0.1016 m)/(0.086 m/d) = 1.2 d (based on i = 0.0004).

Based on the above calculations, sampling every other day would provide the required independent samples. However, a "disturbed zone" due to purging may create a larger "effective" diameter than used in the above calculation. Therefore, to account for the disturbed zone and/or to reduce the autocorrelation effects (which may happen if groundwater is sampled too close in time), a monthly sampling interval is recommended. Sampling will be accomplished in months when the water level is high (March, April, May, and June) and again when the water level is low (September, October, November, and December).

4.5.4 Analytical Procedures

The laboratory approved for the groundwater monitoring program will operate under the requirements of current laboratory contracts and will use standard laboratory procedures as listed in the SW-846 (EPA 1986) or an alternate equivalent. Alternate procedures, when used, will meet the guidelines of SW-846, Chapter 1.0. Analytical methods and quality control for the RCRA groundwater monitoring activities are described in WHC (1993).

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4.5.5 Geochemical Evaluation of Iron and Manganese

The hypothesis that elevated iron and manganese is due to reducing conditions in certain wells completed at the bottom of the unconfined aquifer will be tested by analyzing key redox (oxidation-reduction) indicator parameters:

- Fe II
- dissolved oxygen
- Eh.

Under reducing conditions, low dissolved oxygen (<1 ppm) and low or negative redox potentials (Eh) (see Figure 4-3), iron and manganese associated with sediments as oxide coatings on mineral grains can be converted to lower oxidation states (Fe^{+2} and Mn^{+2}). This results in dissolution at the solid-liquid interface (i.e., between pore fluid and surfaces of the oxide coatings). The resultant manganese and iron dissolved in the pore fluid is thus free to pass through a membrane filter when the sample is pumped from the well and directly through the filter holder at the well head. The occurrence of elevated iron and manganese under the above conditions is thus a natural consequence of the aquifer host material (i.e., presence of oxide coatings) and the isolation of the test zone from atmospheric oxygen.

The location of the screened interval at the bottom of the aquifer for the two "deep" wells in the 300 APT with anomalous dissolved iron and manganese and the correspondingly low hydraulic conductivities (wells -15B and -17B) support the "redox" hypothesis. The additional hydrochemical measurements needed to test the hypothesis will be made in the field using (1) a special sample pump to ensure that in-leakage of air (oxygen) does not occur during sample extraction and (2) flow-through test equipment to record dissolved oxygen, Eh, temperature, and pH continuously during an extended purge cycle (up to six bore volumes). Confirmatory measurements of divalentiron will be made in the field using HACH™ kit methods. Low dissolved oxygen (<1 ppm) low or negative Eh potentials, and the presence of Fe^{+2}, will be taken as indirect evidence for accepting the hypothesized natural occurrence of elevated manganese and iron.

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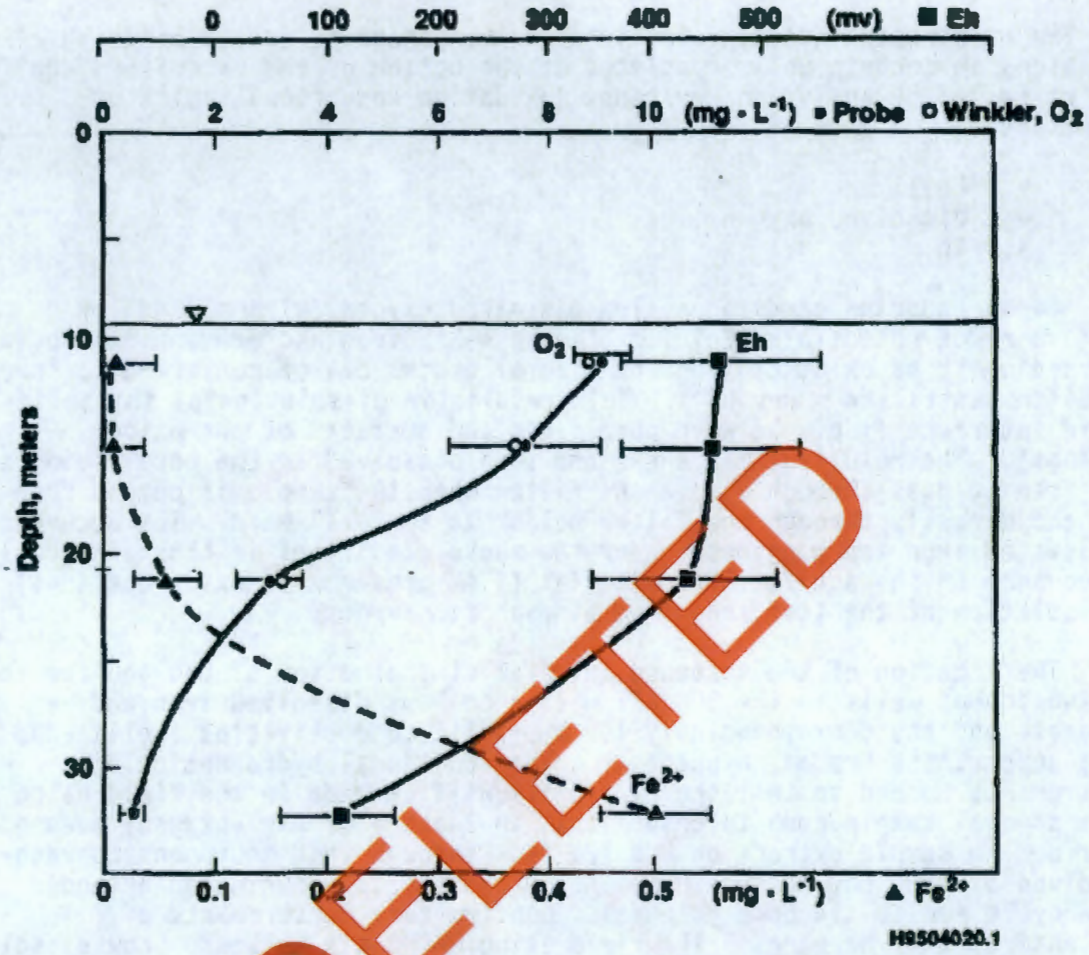
4.6 STATISTICAL METHODS

Section 4.6 proposes statistical evaluation procedures for use with the 300 APT monitoring program. Statistical evaluation of groundwater monitoring data will comply with requirements set forth in the WAC 173-303-645 (8)(h) final status regulations. Specifically, procedures outlined in the following EPA technical guidance documents will be followed:

- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Interim Final Guidance* (EPA 1989)

- *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance* (EPA 1992).

Figure 4-3. Profiles of Eh, Dissolved Oxygen, and Ferrous Ion with Depth.



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For a compliance-level groundwater monitoring program, the monitoring objective is to determine if a groundwater concentration limit such as an MCL has been exceeded. This is a very different problem than the detection-level monitoring where the objective is to detect leakage from the unit by employing upgradient/downgradient comparisons.

4.6.1 Tolerance Intervals

For a compliance-level groundwater monitoring program, the choice of an appropriate statistical test depends on the type of groundwater concentration limit. For health-based concentration values (e.g., an MCL or an ACL derived from health-based risk data), the tolerance interval approach is recommended (EPA 1992, page 50). A tolerance interval is constructed in such a way that it contains at least a specified proportion, P, of the population with a specified confidence coefficient, $100(1 - \alpha)\%$. The proportion of the population included, P, is referred to as the coverage. The probability, $100(1 - \alpha)\%$, with which the tolerance interval includes the proportion P% is referred to as the tolerance coefficient. If compliance data follow a normal or a log-normal distribution, an upper 95% one-sided tolerance limit with a 95% confidence is recommended to be calculated for each constituent of concern in each compliance well (EPA 1989, 1992). If the upper tolerance limit from any compliance well exceeds a MCL, it is interpreted as significant evidence that more than 5% of all compliance values exceed the fixed limit (e.g., MCL). Parametric tolerance limits (suitable for normally or log-normally distributed data) are of the form:

$$\bar{x} + ks \qquad (one\text{-}sided)$$

where $\bar{x}$ is the sample mean; s is the sample standard deviation; and k is a multiplier based on the coverage, the confidence level, and sample size. Values of k can be obtained from EPA (1989). To reduce uncertainty in the estimates of the mean and standard deviation, at least 8 to 10 samples (from each compliance well) are needed.

When the normal or log-normal distribution cannot be justified, especially when a large portion of the samples are non-detects, the use of nonparametric tolerance intervals should be considered. The upper tolerance limit is usually the maximum observed observation from each compliance well for each semiannual sampling event.

Because the parametric tolerance interval approach depends heavily on the normal or log-normal assumption, the adequacy of this assumption should be assessed by probability plots and/or statistical goodness-of-fit tests, such as the Shapiro-Wilk test or Lilliefors test of normality (Gilbert 1987, Conover 1980). Unfortunately, all of the available tests for normality of data do not exhibit high degrees of power when the sample size is small (i.e., <20 to 30 observations). In a compliance monitoring program, it is impractical to obtain 30 independent samples during each semiannual sampling event. Therefore, a nonparametric tolerance interval approach should be considered for the 300 APT. One advantage is that, unless all the sample data are non-detect, the maximum value will be a detected concentration, leading to

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a well-defined upper tolerance. However, the nonparametric tolerance intervals require a large number of samples to provide a reasonable coverage and tolerance coefficient.

In order to have a minimum coverage of 95% with 95% confidence, 59 samples are needed. This means one would be 95% sure that at least 95% of the population measurements will fall below the maximum value based on 59 observations. When the maximum value (from four samples) is chosen as the upper tolerance limit, the average coverage (not the minimum coverage as discussed above) is 80%. That is, one would expect that on average that 80% of the population from that compliance well will be below the maximum value. More samples are needed to achieve a higher coverage. It can be shown that at least 19 samples (per compliance well per semiannual period) are necessary to achieve 95% coverage on average. For the purpose of this monitoring plan, it is assumed that a 80% average coverage is acceptable because (1) a very large amount of hydrogeologic and contaminant data have been collected from the 300 APT wells since 1987 and (2) the rate, extent, and concentrations of groundwater contaminants originating from the 300 APT are well understood.

4.6.2 Confirmation Sampling

For tolerance limits to be useful resampling has to be allowed before a decision is reached. This is because tolerance limits have a built-in failure rate of (1 - P)%. For example, one would expect 1 in every 20 samples to be outside of the upper 95% tolerance limit just by chance. To decrease the chance of a false positive decision because of either the built-in failure rate or the effects of gross errors in sampling or analysis, verification resampling is necessary. This is the best available approach to balance false positive and false negative decisions (Gibbons 1994). In case of an <u>initial exceedance</u>, a verification sampling is needed to determine if the exceedance is an artifact caused by an error in sampling, analysis, or statistical evaluation or natural variation in the groundwater. Recent EPA guidance (1992) encourages the use of resamples as a means to reduce the facility-wide false positive rate.

Confirmation retesting can be accomplished by taking a specific number of additional, <u>independent</u> samples from the well where a specific constituent triggers the initial exceedance. Because more independent data are added to the overall testing procedure, retesting of additional samples, in general, will make the statistical test more powerful and result in a more reliable determination of possible exceedance. Therefore, the objectives for the verification sampling are to ensure (1) quick identification and confirmation of contamination exceeding some standard, if any, and (2) the statistical independence of successive resamples from any well where initial exceedance occurred. The performance of the statistical retesting strategy depends substantially on the independence of the data from each well.

After considerations cited above, it is proposed to obtain two independent samples, split each sample, and send the splits to two different laboratories for independent verification. In this way, laboratory bias (if present) can be investigated. A statistically significant result will be declared only if all resamples are larger than the MCL. If all resamples are

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below the MCL, the compliance monitoring program will continue. If results are inconclusive, another round of verification resamples will be initiated.

Finally, if the magnitude of the initial exceedance is small (e.g., <25%), special analysis may be requested in order to achieve lower detection limits and/or improved accuracy and precision.

4.6.3 Non-detects

Non-detects will be handled per recommendations stated in the EPA guidance documents (1989 and 1992). Non-detects will not present a problem in using a nonparametric method to evaluate compliance data if the detection limit is lower than the MCL. If a parametric statistical method is used, then the handling of non-detects will depend on the percentage of detected values. Basically, a substitution method (use 1/2 of the detection limit to replace non-detects) will be used if less than 15% of all samples are non-detects. If the percent of non-detects is between 15% to 50%, either Cohen's method or Aitchison's adjustments will be used. Detailed descriptions of these methods can be found in EPA (1989 and 1992). When more than 50% of the sample values are non-detects, the Poisson model may be used to derive a Poisson tolerance limit. Steps to calculate an upper tolerance limit using the Poisson model are given in EPA (1992).

4.6.4 Outliers

An outlier is an observation that does not conform to the pattern established by other observations in the data set. Possible reasons for its occurrence include contaminated sampling equipment, inconsistent sampling or analytical procedure, data transcribing error, and true but extreme measurements. Statistical methods such as Grubbs' methods (Grubbs 1969) for testing of outliers and/or the box-and-whisker plot (Ostle and Malone 1988) may be used. Once an observation is found to be an outlier, the following action should be taken:

- If the error can be identified and the correct value can be recovered through the Request for Analytical Data Review (RADE) process (see Section 5.1), replace the outlier value with the corrected value.

- If the error can be documented but the correct value cannot be recovered, the outlier should be deleted. Describe this deletion in the statistical report.

- If no error can be documented, then assume that the value is a valid measurement. However, obtain another sample to confirm the high value, if necessary.

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4.7 DETERMINING RATE AND DIRECTION OF GROUNDWATER FLOW

Depth to water will be measured in 32 300 Area wells semiannually in order to construct water table maps. These maps will be used to interpret the direction of groundwater flow and to derive the water table gradient. The gradient, in turn, will be used with estimated values of hydraulic conductivity and effective porosity to calculate flow rate by using the Darcy equation (see Section 3.2). Because the 300 Area water table is significantly affected by Columbia River level, the semiannual measurements will be coordinated with seasonal fluctuations of Columbia River stage in order to construct water table maps corresponding to high and low stages. Historically, high river stage is somewhere in the months of May or June, and low river stage occurs in September. Therefore, the semiannual measurements will be in September and in either May or June. Exact times of measurement will be adjusted to ensure that high and low stages are represented. The wells measured semiannually for water level are listed in Table 4-6 and shown in Figure 3-1. Water levels will be measured and recorded as specified in EII 10.2 (WHC 1988).

In addition to the 32 wells measured semiannually for constructing water table maps, 8 other wells will be measured semiannually to determine hydraulic head of the lower portion of the unconfined aquifer (4 wells) and upper confined aquifer (4 wells). The wells measured in the lower portion of the unconfined aquifer are 399-1-10B, 399-1-16B, 399-1-17B, and 399-1-18B. Wells measured in the uppermost confined aquifer are 399-1-9, 399-1-16C, 399-1-17C, and 399-1-18C. Figure 3-1 shows the well locations.

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Table 4-6. Wells Used for Semiannual Depth-to-Water Measurements.

Wells Monitoring the Top of the Unconfined Aquifer

399-1-1	399-1-18A	399-2-2	399-4-10
-1-10A	-1-19	-2-3	-4-11
-1-11	-1-3	-3-1	-5-1
-1-12	-1-4	-3-6	-6-1
-1-14A	-1-5	-3-9	-8-1
-1-15	-1-7	-3-10	-8-2
-1-16A	-1-8	-4-1	-8-3
-1-17A	-2-1	-4-7	699-S27-E14

Wells Monitoring the Bottom of the Unconfined Aquifer

399-1-10B	399-1-16B	399-1-17B	399-1-18B

Wells Monitoring the Uppermost Confined Aquifer

399-1-9	399-1-16C	399-1-17C	399-1-18C

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5.0 DATA MANAGEMENT AND REPORTING

5.1 DATA VERIFICATION AND VALIDATION

All contract analytical laboratory results are entered into the HEIS database. Data from this larger database are downloaded to smaller data sets for data validation, data reduction, and trend analysis. Data verification and validation activities should follow WHC-CM-7-8, Section 2.6, "Validation and Verification of RCRA Groundwater Data" (WHC 1992). Suspected data are submitted for formal review and resolution through the RADE process per Section 4.2, "Evaluation of Requests for Analytical Data Review" (WHC 1992). Results of data verification and validation shall be reported in the RCRA quarterly and annual reports.

5.2 REPORTING

The results of statistical evaluation will be reported to Ecology in the RCRA quarterly and annual monitoring reports. The statistical results will include a list of groundwater parameters analyzed, detection limits, and analytical results. If a statistically significant exceedance (after the confirmation resampling evaluation process) is determined at any well at the POC, the following steps will be taken per WAC 173-303-645(10)(g)(i)(ii).

- Notify Ecology in writing within 7 days of the finding with a report indicating which concentration limits have been exceeded.
- Submit an application for a permit modification to establish a corrective action program to Ecology in 90 days.

In case of a false positive claim, the following procedures will be taken per WAC 173-303-645(10)(i)(i).

- Notify Ecology in writing within 7 days of the finding (i.e., exceedance) that a false positive claim will be made.
- Submit a report to Ecology within 45 days. This report should demonstrate that a source other than the 300 APT caused the standard(s) to be exceeded or that the apparent noncompliance with standard(s) resulted from error in sampling, analysis, or evaluation.
- Submit an application for a permit modification to make appropriate changes to the compliance monitoring program within 45 days.
- Continue monitoring in accordance with the compliance monitoring program.

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6.0 CORRECTIVE ACTION PROGRAM

If, at the POC, dangerous waste constituents of concern are measured in the groundwater at concentrations that exceed the applicable groundwater concentration limit, a corrective action level monitoring program will be established. The development of a corrective action level monitoring program will be initiated by integration of RCRA/CERCLA programs. Groundwater monitoring will continue as described in Chapters 4.0 and 5.0. Implementation of the corrective action will be deferred and integrated with the remediation of the 300-FF-1 (source) and 300-FF-5 (groundwater) operable units.
A description of the groundwater monitoring plan that will be used to assess the effectiveness of the corrective/remedial action measures will be submitted when the need for corrective action is first identified.

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APPENDIX A

SUMMARY OF CONSTITUENTS SAMPLED TO 1988
(Taken from Schalla et al. 1988a, Table 6)

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-Constituent List-Contamination Indicators-

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
101	CONDUCT	UMHO	.	173	0		.		Conductivity
109	PH		.	172	0				pH
C08	TOX	PPB	100	107	168		.		Total organic halogen
C09	TOC	PPB	1000	167	106		.		Total organic carbon

-Constituent List-Drinking Water Standards-

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
109	COLIFRM	MPN	3	211	195		1	EPA	Coliform bacteria
111	BETA	PCI/L	6	210	4		50	EPA	Gross beta
101	RADIUM	PCI/L	1	210	198		5	EPA	Radium
212	GROALPHA	PCI/L	4	210	3		15	EPA	Gross alpha
A05	BARIUM	PPB	6	216	17		1000	EPA	Barium
A07	CADMIUM	PPB	2	216	201		10	EPA	Cadmium
A08	CHROMIUM	PPB	10	216	200		50	EPA	Chromium
A10	SILVER	PPB	10	216	216		50	EPA	Silver
A20	ARSENIC	PPB	5	216	199		50	EPA	Arsenic
A21	MERCURY	PPB	.1	216	197		2	EPA	Mercury
A22	SELENIUM	PPB	5	216	212		10	EPA	Selenium
A33	ENDRIN	PPB	1	216	216	***	.2	EPA	Endrin
A34	METHLOR	PPB	1	216	216	***	100	EPA	Methoxychlor
A35	TOXAENE	PPB	1	216	216	***	5	EPA	Toxaphene
A36	a-BHC	PPB	1	216	216	***	4	EPA	Alpha-BHC
A37	b-BHC	PPB	1	216	216	***	4	EPA	Beta-BHC
A38	g-BHC	PPB	1	216	216	***	4	EPA	Gamma-BHC
A39	d-BHC	PPB	1	216	216	***	4	EPA	Delta-BHC
A51	LEADGF	PPB	5	216	182		20	EPA	Lead (graphite furnace)
C72	NITRATE	PPB	500	211	0		45000	EPA	Nitrate
C74	FLUORID	PPB	500	211	131		1400	EPA	Fluoride
H13	2,4-D	PPB	1	214	214	***	100	EPA	2,4-D
H14	2,4,5TP	PPB	1	214	214	***	10	EPA	2,4,5-TP silvex

-Constituent List-Quality Characteristics-

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
A11	SODIUM	PPB	100	216	0		.		Sodium
A17	MANGESE	PPB	6	216	182		.		Manganese
A19	IRON	PPB	50	216	86		.		Iron
C67	PHENOL	PPB	10	216	216	***	.		Phenol
C73	SULFATE	PPB	500	211	0		.		Sulfate
C76	CHLORID	PPB	500	211	0		.		Chloride

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Constituent List-Site Specific

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
A12	NICKEL	PPB	10	216	202		.		Nickel
A13	COPPER	PPB	10	216	138		1300	EPAP	Copper
A15	ANTIMNY	PPB	100	216	216	***	.		Antimony
A16	ALUMNUM	PPB	150	216	169		.		Aluminum
A24	THIOURA	PPB	200	211	209		.		Thiourea
A61	TETRANE	PPB	10	216	216	***	5	EPAP	Tetrachloromethane
A62	BENZENE	PPB	10	216	216	***	5	EPAP	Benzene
A63	DIOXANE	PPB	600	216	216	***	.		Dioxane
A64	METHONE	PPB	10	216	215		.		Methyl ethyl ketone
A65	PYRIDIN	PPB	500	216	216	***	.		Pyridine
A66	TOLUENE	PPB	10	216	216	***	2000	EPAP	Toluene
A67	1,1,1-T	PPB	10	216	214		200	EPAP	1,1,1-trichloroethane
A68	1,1,2-T	PPB	10	216	214		.		1,1,2-trichloroethane
A69	TRICENE	PPB	10	216	212		5	EPAP	Trichloroethylene
A70	PERCENE	PPB	10	216	195		.		Perchloroethylene
A71	OPXYLE	PPB	10	216	216	***	440	EPAP	Xylene-o,p
B14	M-XYLE	PPB	10	216	216	***	440	EPAP	Xylene-m
B61	12-dben	PPB	10	216	216	***	.		1,2-dichlorobenzene
B62	13-dben	PPB	10	216	216	***	.		1,3-dichlorobenzene
B63	14-dben	PPB	10	216	216	***	.		1,4-dichlorobenzene
C36	PENTCHB	PPB	10	216	216	***	.		Pentachlorobenzene
C37	TETRCHB	PPB	10	216	216	***	.		1,2,4,5-tetrachlorobenzene
C43	TRICHLB	PPB	10	216	216	***	.		1,2,4-trichlorobenzene
C54	HEXACHL	PPB	10	216	216	***	.		Hexachlorophene
C55	NAPHTHA	PPB	10	216	216	***	.		Naphthalene
C56	123TRI	PPB	10	216	216	***	.		1,2,3-trichlorobenzene
C58	135TRI	PPB	10	216	216	***	.		1,3,5-trichlorobenzene
C59	1234TE	PPB	10	216	216	***	.		1,2,3,4-tetrachlorobenzene
C60	1236TE	PPB	10	216	216	***	.		1,2,3,5-tetrachlorobenzene
C70	CYANIDE	PPB	10	211	208		.		Cyanide
C71	FORMALN	PPB	500	216	216	***	.		Formalin
C78	SULFIDE	PPB	1000	211	209		.		Sulfide
C79	KEROSEN	PPB	10000	216	216	***	.		Kerosene
C80	AMMONIU	PPB	20	211	208		.		Ammonium ion
C81	ETHYGLY	PPB	10000	211	211	***	.		Ethylene glycol
C88	DIOXIN	PPB	.1	216	216	***	.		Dioxin

Constituent List-Tag-along

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
A14	VANADUM	PPB	5	216	118		.		Vanadium
A18	POTASUM	PPB	100	216	3		.		Potassium
A88	CHLFORM	PPB	10	116	24		.		Chloroform
A93	METHYCH	PPB	10	86	14		.		Methylene chloride
B89	HEXCBEN	PPB	10	216	216	***	.		Hexachlorobenzene
C62	HEXAERE	PPB	10	164	164	***	.		Hexachloroprepene
C82	CHLLATE	PPB	100	108	108	***	.		Chlorobenzilate
C76	PHOSPHA	PPB	1000	211	210		.		Phosphate
C91	STRYCHN	PPB	50	108	108	***	.		Strychnine
C92	MALHYDR	PPB	500	108	108	***	.		Maleic hydrizide
C93	NICOTIN	PPB	100	108	108	***	.		Nicotinic acid

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Constituent List-WAC 173-303-9906

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELGUDL	ALLBELOW	MANLIMIT	REGAGEN	FULLNAME
A01	BERYLAM	PPB	5	16	16	***			Beryllium
A02	OSMIUM	PPB	300	16	16	***			Osmium
A03	STRONUM	PPB	300	16	16	***			Strontium
A04	ZINC	PPB	5	16	5				Zinc
A05	CALCIUM	PPB	50	16	8				Calcium
A23	THALIUM	PPB	10	16	15				Thallium
A25	ACETREA	PPB	200	16	16	***			1-acetyl-2-thiourea
A26	CHLOREA	PPB	200	16	16	***			1-(o-chlorophenyl) thiourea
A27	DIETROL	PPB	200	16	16	***			Diethylstilbesterol
A28	ETHYREA	PPB	200	16	16	***			Ethylenethiourea
A29	NAPHREA	PPB	200	16	16	***			1-naphthyl-2-thiourea
A32	PHENREA	PPB	200	16	16	***			N-phenylthiourea
A40	DDD	PPB	1	16	16	***			DDD
A41	DDE	PPB	1	16	16	***			DDE
A42	DDT	PPB	1	16	16	***			DDT
A43	HEPTLOR	PPB	1	16	16	***	0	EPAP	Heptachlor
A44	HEPTIDE	PPB	1	16	16	***	0	EPAP	Heptchlor epoxide
A46	DIELRIN	PPB	1	16	16	***			Dieldrin
A47	ALDRIN	PPB	1	16	16	***			Aldrin
A48	CHLDANE	PPB	1	16	16	***	0	EPAP	Chlordane
A49	ENDO1	PPB	1	16	16	***			Endosulfan I
A52	ENDO2	PPB	1	2	2	***			Endosulfan II
A72	ACROLIN	PPB	10	16	16	***			Acrolein
A73	ACRYLE	PPB	10	16	16	***			Acrylonitrile
A74	BISTHER	PPB	10	16	16	***			Bis(chloroethyl) ether
A75	BROMONE	PPB	10	16	16	***			Bromoacetone
A76	METHBRO	PPB	10	16	16	***			Methyl bromide
A77	CARBIDE	PPB	10	16	16	***			Carbon disulfide
A78	CHLBENZ	PPB	10	16	16	***			Chlorobenzene
A79	CHLTHER	PPB	10	16	16	***			2-chloroethyl vinyl ether
A81	METHCHL	PPB	10	16	16	***			Methyl chloride
A82	CHMTHER	PPB	10	16	16	***			Chloromethyl methyl ether
A83	CROTONA	PPB	10	16	16	***			Crotonaldehyde
A84	DIBRCHL	PPB	10	16	16	***			1,2-dibromo-3-chloropropane
A86	DIBRETH	PPB	10	16	16	***			1,2-dibromoethane
A88	DIBRMET	PPB	10	16	16	***			Dibromomethane
A87	DIBUTEN	PPB	10	16	16	***			1,4-dichloro-2-butene
A88	DICDIFM	PPB	10	16	16	***			Dichlorodifluoromethane
A89	1,1-DIC	PPB	10	16	16	***			1,1-dichloroethane
A90	1,2-DIC	PPB	10	16	16	***	5	EPAP	1,2-dichloroethane
A91	TRANDCE	PPB	10	16	16	***	70	EPAP	Trans-1,2-dichloroethene
A92	DICETHY	PPB	10	16	16	***	7	EPAP	1,1-dichloroethylene
A94	DICPANE	PPB	10	16	16	***	0	EPAP	1,2-dichloropropane
A95	DICPENE	PPB	10	16	16	***			1,3-dichloropropene
A96	HNDIETH	PPB	10	16	16	***			N,N-diethylhydrazine
A97	1,1-DIM	PPB	3000	16	16	***			1,1-dimethylhydrazine
A98	1,2-DIM	PPB	3000	16	16	***			1,2-dimethylhydrazine
A99	HYDRSUL	PPB	10	16	16	***			Hydrogen sulfide
B01	IODOMET	PPB	10	16	16	***			Iodomethane
B02	METHACR	PPB	10	16	16	***			Methacrylonitrile

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----------Constituent List-WAC 173-303-9905----------

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
B03	METHTHI	PPB	10	16	16	***	.		Methanethiol
B04	PENTACH	PPB	10	16	16	***	.		Pentachloroethane
B05	1112-tc	PPB	10	16	16	***	.		1,1,1,2-tetrachloroethane
B06	1122-tc	PPB	10	16	16	***	.		1,1,2,2-tetrachloroethane
B08	BROMOFM	PPB	10	16	16	***	.		Bromoform
B09	TRCMEOL	PPB	10	16	16	***	.		Trichloromethanethiol
B10	TRCMFLM	PPB	10	16	16	***	.		Trichloromonofluoromethane
B11	TRCPANE	PPB	10	16	16	***	.		Trichloropropane
B12	123-trp	PPB	10	16	16	***	.		1,2,3-trichloropropane
B13	VINYIDE	PPB	10	16	16	***	1	EPAP	Vinyl chloride
B15	DIETHY	PPB	10	16	16	***	.		Diethylarsine
B19	ACETILE	PPB	10	16	16	***	.		Acetonitrile
B20	ACETONE	PPB	10	16	16	***	.		Acetophenone
B21	WARFRIN	PPB	10	16	16	***	.		Warfarin
B22	ACEFENE	PPB	10	16	16	***	.		2-acetylaminofluorene
B23	AMINOYL	PPB	10	16	16	***	.		4-aminobiphenyl
B24	AMIISOX	PPB	10	16	16	***	.		6-(aminomethyl)-3-isoxazolol
B26	AMITROL	PPB	10	16	16	***	.		Amitrole
B26	ANILINE	PPB	10	16	16	***	.		Aniline
B27	ARAMITE	PPB	10	16	16	***	.		Aramite
B28	AURAMIN	PPB	10	16	16	***	.		Auramine
B29	BENZCAC	PPB	10	16	16	***	.		Benz[c]acridine
B30	BENZAAN	PPB	10	16	16	***	.		Benz[a]anthracene
B31	BENDICM	PPB	10	16	16	***	.		Benzene, dichloromethyl
B32	BENZMOL	PPB	10	16	16	***	.		Benzenethiol
B33	BENDINE	PPB	10	16	16	***	.		Benzidine
B34	BENZBFL	PPB	10	16	16	***	.		Benzo[b]fluoranthene
B35	BENZJFL	PPB	10	16	16	***	.		Benzo[j]fluoranthene
B36	PBENZQU	PPB	10	16	16	***	.		P-benzoquinone
B37	BENZCHL	PPB	10	16	16	***	.		Benzyl chloride
B38	BIS2CHM	PPB	10	16	16	***	.		Bis(2-chloroethoxy) methane
B39	BIS2CHE	PPB	10	16	16	***	.		Bis(2-chloroethyl) ether
B40	BIS2EPH	PPB	10	28	16		.		Bis(2-ethylhexyl) phthalate
B41	BROPHEN	PPB	10	16	16	***	.		4-bromophenyl phenyl ether
B42	BUTBENP	PPB	10	16	16	***	.		Butyl benzyl phthalate
B43	BUTDINP	PPB	10	16	16	***	.		2-sec-butyl-4,6-dinitrophenol
B44	CHALETH	PPB	10	16	16	***	.		Chloroalkyl ethers
B46	CHLANIL	PPB	10	16	16	***	.		P-chloroaniline
B46	CHLCRES	PPB	10	16	16	***	.		P-chloro-m-cresol
B47	CHLEPOX	PPB	10	16	16	***	.		1-chloro-2,3-epoxypropane
B48	CHLNAPH	PPB	10	16	16	***	.		2-chloronaphthalene
B49	CHLPHEN	PPB	10	16	16	***	.		2-chlorophenol
B50	CHRYSEN	PPB	10	16	16	***	.		Chrysene
B51	CRESOLS	PPB	10	16	16	***	.		Cresols
B52	CYCHDIN	PPB	10	16	16	***	.		2-cyclohexyl-4,6-dinitrophenol
B53	DIBAHAC	PPB	10	16	16	***	.		Dibenz[a,h]acridine
B54	DIBAJAC	PPB	10	16	16	***	.		Dibenz[a,j]acridine
B55	DIBAHAN	PPB	10	16	16	***	.		Dibenz[a,h]anthracene
B56	DIBCGCA	PPB	10	16	16	***	.		7H-dibenzo[c,g]carbazole
B57	DIBAEPY	PPB	10	16	16	***	.		Dibenzo[a,e]pyrene

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----------Constituent List-WAC 173-303-9906----------

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
B58	DIBANPY	PPB	10	10	10	***		.	Dibenzo[a,h]pyrene
B59	DIBAIPY	PPB	10	10	10	***		.	Dibenzo[a,i]pyrene
B60	DIBPHTH	PPB	10	10	10	***		.	Di-n-butyl phthalate
B64	DICHBEN	PPB	10	10	10	***		.	3,3'-dichlorobenzidine
B65	24-dchp	PPB	10	10	10	***		.	2,4-dichlorophenol
B66	26-dchp	PPB	10	10	10	***		.	2,6-dichlorophenol
B67	DIEPHTH	PPB	10	10	10	***		.	Diethyl phthalate
B68	DIHYSAF	PPB	10	10	10	***		.	Dihydrosafrole
B69	DIMETHB	PPB	10	10	10	***		.	3,3'-dimethoxybenzidine
B70	DIMEANB	PPB	10	10	10	***		.	P-dimethylaminoazobenzene
B71	DIMBENZ	PPB	10	10	10	***		.	7,12-dimethylbenz[a]anthracene
B72	DIMEYLB	PPB	10	10	10	***		.	3,3'-dimethylbenzidine
B73	THIONBX	PPB	10	10	10	***		.	Thiofanox
B74	DIMPHAM	PPB	10	10	10	***		.	Alpha,alpha-dimethylphenethylamine
B76	DIMPHEN	PPB	10	10	10	***		.	2,4-dimethylphenol
B78	DIMPHTH	PPB	10	10	10	***		.	Dimethyl phthalate
B77	DINBENZ	PPB	10	10	10	***		.	Dinitrobenzene
B78	DINCRES	PPB	10	10	10	***		.	4,6-dinitro-o-cresol and salts
B79	DINPHEN	PPB	10	10	10	***		.	2,4-dinitrophenol
B80	24-dint	PPB	10	10	10	***		.	2,4-dinitrotoluene
B81	26-dint	PPB	10	10	10	***		.	2,6-dinitrotoluene
B82	DIOPHTH	PPB	10	10	10	***		.	Di-n-octyl phthalate
B83	DIPHAMI	PPB	10	10	10	***		.	Diphenylamine
B84	DIPHHYD	PPB	10	10	10	***		.	1,2-diphenylhydrazine
B86	DIPRNIT	PPB	10	10	10	***		.	Di-n-propylnitrosamine
B88	ETHYIME	PPB	10	10	10	***		.	Ethylenimine
B87	ETMSETH	PPB	10	10	10	***		.	Ethyl methanesulfonate
B89	FLUORAN	PPB	10	10	10	***		.	Fluoranthene
B90	HEXCBUT	PPB	10	10	10	***		.	Hexachlorobutadiene
B91	HEXCCYC	PPB	10	10	10	***		.	Hexachlorocyclopentadiene
B92	HEXCETH	PPB	10	10	10	***		.	Hexachloroethane
B93	INDENOP	PPB	10	10	10	***		.	Indeno[1,2,3-cd]pyrene
B94	ISOSOLE	PPB	10	10	10	***		.	Isosafrole
B95	MALOILE	PPB	10	10	10	***		.	Malononitrile
B96	MELPHAL	PPB	10	10	10	***		.	Melphalan
B97	METHAPY	PPB	10	10	10	***		.	Methapyrilene
B98	METHNYL	PPB	10	10	10	***		.	Methylenyl
B99	METAZIR	PPB	10	10	10	***		.	2-methylaziridine
C01	METCHAN	PPB	10	10	10	***		.	3-methylcholanthrene
C02	METBISC	PPB	10	10	10	***		.	4,4'-methylenebis(2-chloroaniline)
C03	METACIB	PPB	10	10	10	***		.	2-methylacetonitrile
C04	METACRY	PPB	10	10	10	***		.	Methyl methacrylate
C05	METMSUL	PPB	10	10	10	***		.	Methyl methanesulfonate
C06	METPROP	PPB	10	10	10	***		.	2-methyl-2-(methylthio) propionaldehyde-o-
C07	METHIOU	PPB	10	10	10	***		.	Methylthiouracil
C08	NAPHQUI	PPB	10	10	10	***		.	1,4-naphthoquinone
C09	1-napha	PPB	10	10	10	***		.	1-naphthylamine
C10	2-napha	PPB	10	10	10	***		.	2-naphthylamine
C11	NITRANI	PPB	10	10	10	***		.	P-nitroaniline
C12	NITBENZ	PPB	10	10	10	***		.	Nitrobenzene

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----------Constituent List=WAC 173-303-9906----------

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REQAGEN	FULLNAME
C13	NITPHEN	PPB	10	16	16	***	.		4-nitrophenol
C14	NNIBUTY	PPB	10	16	16	***	.		N-nitrosodi-n-butylamine
C15	NNIDIEA	PPB	10	16	16	***	.		N-nitrosodiethanolamine
C16	NNIDIET	PPB	10	16	16	***	.		N-nitrosodiethylamine
C17	NNIDIME	PPB	10	16	16	***	.		N-nitrosodimethylamine
C18	NNIMETH	PPB	10	16	16	***	.		N-nitrosomethylethylamine
C19	NNIURET	PPB	10	16	16	***	.		N-nitroso-N-methylurethane
C20	NNIVINY	PPB	10	16	16	***	.		N-nitrosomethylvinylamine
C21	NNIMORP	PPB	10	16	16	***	.		N-nitrosomorpholine
C22	NNINICO	PPB	10	16	16	***	.		N-nitrosonornicotine
C23	NNIPIPE	PPB	10	16	16	***	.		N-nitrosopiperidine
C24	NITRPYR	PPB	10	16	16	***	.		Nitrosopyrrolidine
C25	NITRTOL	PPB	10	16	16	***	.		5-nitro-o-toluidine
C27	PENTCHN	PPB	10	16	16	***	.		Pentachloronitrobenzene
C28	PENTCHP	PPB	10	16	16	***	220	EPAP	Pentachlorophenol
C29	PHENTIN	PPB	10	16	16	***	220	EPAP	Phenacetin
C30	PHENINE	PPB	10	16	16	***	.		Phenylenediamine
C31	PHTHEST	PPB	10	16	16	***	.		Phthalic acid esters
C32	PICOLIN	PPB	10	16	16	***	.		2-picoline
C33	PROMIDE	PPB	10	16	16	***	.		Promacide
C34	RESERPI	PPB	10	16	16	***	.		Reserpine
C35	RESORCI	PPB	10	16	16	***	.		Resorcinol
C36	SAFROL	PPB	10	16	16	***	.		Safrol
C38	TETRCHP	PPB	10	16	16	***	.		2,3,4,6-tetrachlorophenol
C40	THIURAM	PPB	10	16	16	***	.		Thiuram
C41	TOLUDIA	PPB	10	16	16	***	.		Toluenediamine
C42	OTOLHYD	PPB	10	16	16	***	.		O-toluidine hydrochloride
C44	245-trp	PPB	10	16	16	***	.		2,4,5-trichlorophenol
C46	246-trp	PPB	10	16	16	***	.		2,4,6-trichlorophenol
C46	TRIPHOS	PPB	10	16	16	***	.		O,O,O-triethyl phosphorothioate
C47	SYMTRIN	PPB	10	16	16	***	.		Sym-trinitrobenzene
C48	TRIPHOS	PPB	10	16	16	***	.		Tris(2,3-dibromopropyl) phosphate
C49	BENZOPY	PPB	10	16	16	***	.		Benzo[a]pyrene
C50	CHLNAPH	PPB	10	16	16	***	.		Chlornaphazine
C51	BIS2ETH	PPB	10	16	16	***	.		Bis(2-chloroisopropyl)ether
C53	HYDRAZI	PPB	3000	16	16	***	.		Hydrazine
C81	TETEPYR	PPB	2	16	16	***	.		Tetraethylpyrophosphate
C83	CARBPHT	PPB	2	16	16	***	.		Carbophenothion
C84	DISULFO	PPB	2	16	16	***	.		Disulfoton
C85	DIMETHO	PPB	5	16	16	***	.		Dimethoate
C86	METHPAR	PPB	2	16	16	***	.		Methyl parathion
C87	PARATHI	PPB	2	16	16	***	.		Parathion
C87	CITRUSR	PPB	1000	16	16	***	.		Citrus red
C88	CYANBRO	PPB	3000	16	16	***	.		Cyanogen bromide
C89	CYANCHL	PPB	3000	16	16	***	.		Cyanogen chloride
C90	PARALDE	PPB	3000	16	16	***	.		Paraldehyde
C94	ACRYIDE	PPB	3000	16	16	***	0	EPAP	Acrylamide
C95	ALLYLAL	PPB	3000	16	16	***	.		Allyl alcohol
C96	CHLORAL	PPB	3000	16	16	***	.		Chloral
C97	CHLACET	PPB	3000	16	16	***	.		Chloroacetaldehyde

Constituent List-WAC 173-303-9905

CONCODE	CONNAME	ANALUNIT	DETLIMIT	SAMPLES	BELOWDL	ALLBELOW	MAXLIMIT	REGAGEN	FULLNAME
C98	CHLPROP	PPB	3000	16	16	***	.	.	3-chloropropionitrile
C99	CYANOGN	PPB	3000	16	16	***	.	.	Cyanogen
H01	DICPROP	PPB	3000	16	16	***	.	.	Dichloropropanol
H03	ETHCARB	PPB	3000	16	16	***	.	.	Ethyl carbamate
H04	ETHCYAN	PPB	3000	16	16	***	.	.	Ethyl cyanide
H05	ETHOXID	PPB	3000	16	16	***	.	.	Ethylene oxide
H06	ETHMETH	PPB	3000	16	16	***	.	.	Ethyl methacrylate
H07	FLUOROA	PPB	3000	16	16	***	.	.	Fluoroacetic acid
H08	GLYCIDY	PPB	3000	16	16	***	.	.	Glycidylaldehyde
H09	ISOBUTY	PPB	3000	16	16	***	.	.	Isobutyl alcohol
H10	METZINE	PPB	3000	16	16	***	.	.	Methyl hydrazine
H11	PROPYLA	PPB	3000	16	16	***	.	.	N-propylamine
H12	PROPYNO	PPB	3000	16	16	***	.	.	2-propyn-1-ol
H16	2,4,5-T	PPB	1	14	14	***	.	.	2,4,5-T
I01	ACETONE	PPB	.	2	0		.	.	
I02	HEXANE	PPB	0	2	0		.	.	
I03	MECYPEN	PPB	0	1	0		.	.	
I04	MEBUPHT	PPB	0	1	0		.	.	
I20	TAF	PPB	0	2	0		.	.	
I03	BHT	PPB	.	1	0		.	.	
I99	UNKNOWN	PPB	0	4	0		.	.	

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APPENDIX B

ANALYTICAL DATA, MAY 1986 - JUNE 1988
(Taken from Schalla et al. 1988a, Table 7)

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Constituent List=Contamination Indicators

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
101	CONDUCT	UMHO	173	.	0	.	282	287	86.7	30.7	146	555
100	PH		172	.	0	.	7.03	7.1	0.840	9.2	3.9	8.3
C08	TOX	PPB	187	100	158	.	246	30.3	1010	410.8	2.3	9160
C09	TOC	PPB	187	1000	168	.	1100	933	938	85.8	1	8930

Constituent List=Drinking Water Standards

CONSTIT			SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
109	COLIFRM	MPN	211	3	105	1	[illegible]	3	76.4	793.6	0	1100
111	BETA	PCI/L	210	0	4	50	14.7	12	9.16	62.4	0.719	46
101	RADIUM	PCI/L	210	1	190	5	[illegible]	[illegible].0462	0.120	192.4	-0.121	0.875
212	LOALPHA	PCI/L	210	4	3	15	[illegible]	13.9	11.5	72.0	1.31	67.1
A06	BARIUM	PPB	216	0	17	[illegible]	48.0	53.6	54.4	134.0	6	710
A07	CADMIUM	PPB	216	2	201	10	2.13	2	0.616	29.0	2	7
A05	CHROMUM	PPB	216	10	200	50	11.7	10	17	145.5	10	257
A10	SILVER	PPB	216	10	215	50	10	10	0.012	0.1	10	10
A20	ARSENIC	PPB	216	5	199	[illegible]	5.26	5	1.55	29.5	5	23
A21	MERCURY	PPB	216	0.1	197	2	0.027	0.1	1.0	267.3	0.1	9.0
A22	SELENUM	PPB	216	5	21[illegible]	10	5.14	5	1.08	21.1	5	17
A61	LEADQF	PPB	216	5	19[illegible]	50	5.09	5	4.00	79.0	5	40
C72	NITRATE	PPB	211	500	8	45000	18900	19000	5770	30.5	2900	38000
C74	FLUORID	PPB	211	500	133	1400	578	500	170	30.5	500	1070

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Constituent List-Quality Characteristics

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A11	SODIUM	PPB	216	100	0	.	16300	14700	5106	33.4	1220	29800
A17	MANGESE	PPB	216	5	102	.	8.67	6	75.8	298.5	5	367
A19	IRON	PPB	216	50	68	.	258	81	1088	423.2	0	14900
C73	SULFATE	PPB	211	600	0	.	21700	18200	9770	45.1	6700	53600
C75	CHLORID	PPB	211	500	0	.	14400	11500	10800	75.4	600	72200

Constituent List-Site Specific

	CONSTIT		SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A12	NICKEL	PPB	216	10	202	.	11	10	6.96	63.1	10	95
A13	COPPER	PPB	216	10	130	1300	22.1	10	39.6	178.8	10	510
A16	ALUMNUM	PPB	216	150	169	.	221	150	486	219.6	150	7000
A24	THIOURA	PPB	211	200	209	.	200	200	0.6	30.0	200	1000
A64	METHONE	PPB	216	10	215	.	9.90	10	0.435	4.4	3.7	11
A67	1,1,1-T	PPB	216	10	214	200	10.4	10	4.81	46.1	10	72
A68	1,1,2-T	PPB	216	10	214	.	10.1	10	1	10.0	10	23
A69	TRICENE	PPB	216	10	212	5	9.73	10	1.43	14.7	2.4	14
A70	PERCENE	PPB	216	10	195	.	10.4	10	4.73	45.5	2	55
C70	CYANIDE	PPB	211	10	203	.	10	10	0.314	3.1	10	14
C73	SULFIDE	PPB	211	1000	200	.	1020	1000	187	18.4	1000	3000
C80	AMMONIU	PPB	211	50	89	.	120	110	70.2	58.0	30	360

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Constituent List=Tag-along

	CONSTIT	SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A14	VANADUM PPB	218	5	110	.	8.85	5	6.46	87.7	5	36
A18	POTASUM PPB	216	100	3	.	3898	3630	1600	38.8	100	8610
A80	CHLFORM PPB	118	10	24	.	14.3	13	6.82	49.1	4.1	42
A93	METHYCN PPB	66	16	14	.	787	115	3388	428.0	3	27500
C70	PHOSPHA PPB	211	1000	210	.	1010	[illegible]	164	16.3	1000	3240

Constituent List=WAC 173-303-9905

	CONSTIT	SAMPLES	DETLIMIT	BELOWDL	MAXLIMIT	MEAN	MEDIAN	STDDEV	COEFFVAR	MINIMUM	MAXIMUM
A04	ZINC PPB	16	5	5	.	[illegible]	14	44.4	141.0	5	170
A05	CALCIUM PPB	16	50	0	.	31900	29500	12700	39.8	17900	51700
A23	THALIUM PPB	16	10	15	.	10	10	0	0.0	10	10
B40	DIS2EPH PPB	20	10	16	.	14.9	10	12.3	82.5	10	59
I01	ACETONE PPB	2	.	0	.	26	20	8.49	42.4	14	26
I02	HEXANE PPB	2	5	0	.	60	60	0	0.0	60	60
I03	MECYPEN PPB	1	0	0	.	16	16	.	.	16	16
I04	MEBUPNT PPB	1	0	0	.	0	0	.	.	0	0
I20	TAF PPB	2	0	0	.	81.5	81.5	41.7	67.0	32	91
I63	BHT PPB	1	.	0	.	3.2	3.2	.	.	3.2	3.2
I99	UNKNOWN PPB	4	0	0	.	17.4	13	11.7	66.9	10	36

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APPENDIX C

CONCENTRATION VS. TIME PLOTS FOR DETECTED CONSTITUENTS AND CONSTITUENTS EXCEEDING MCLs

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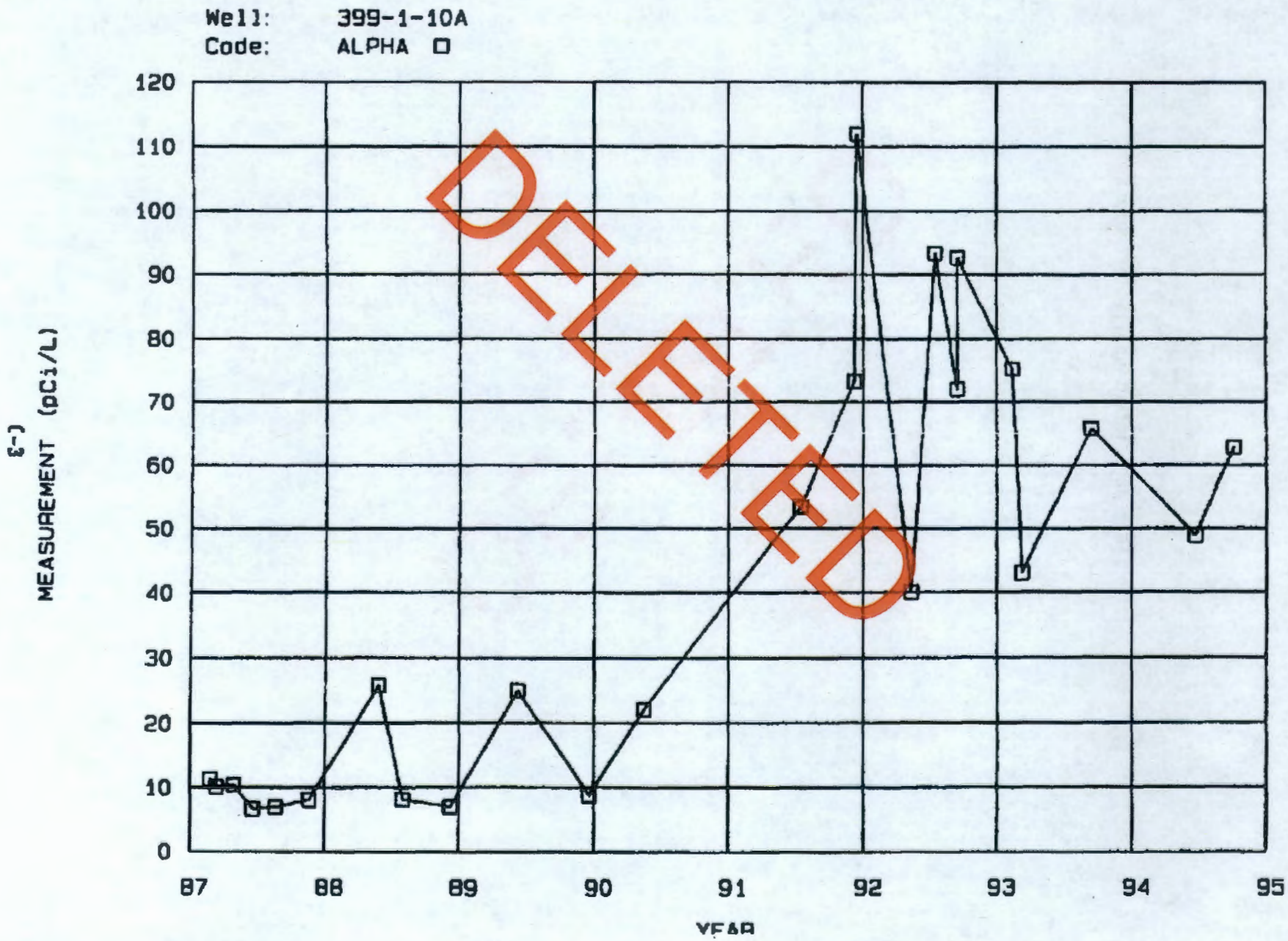
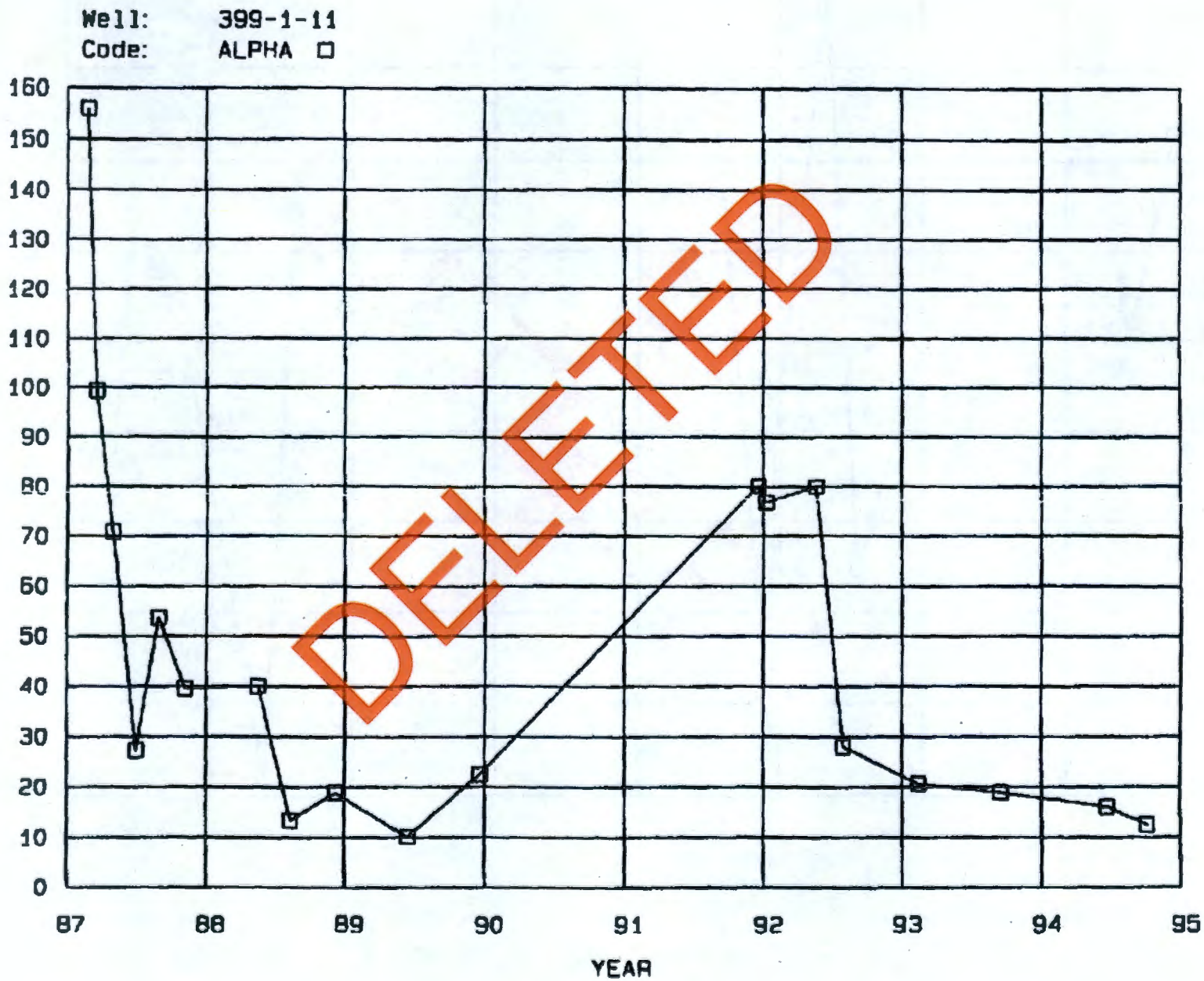
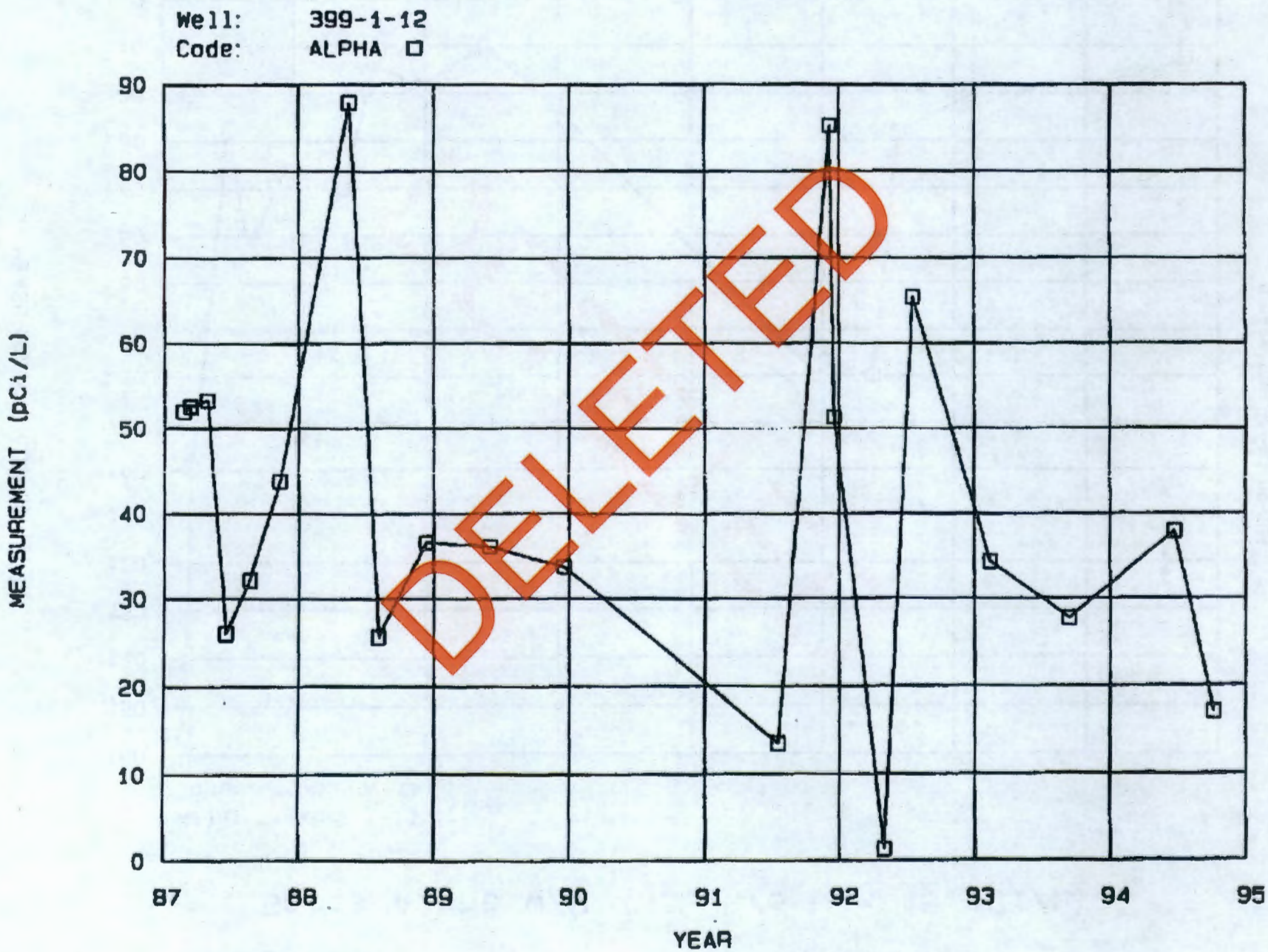
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



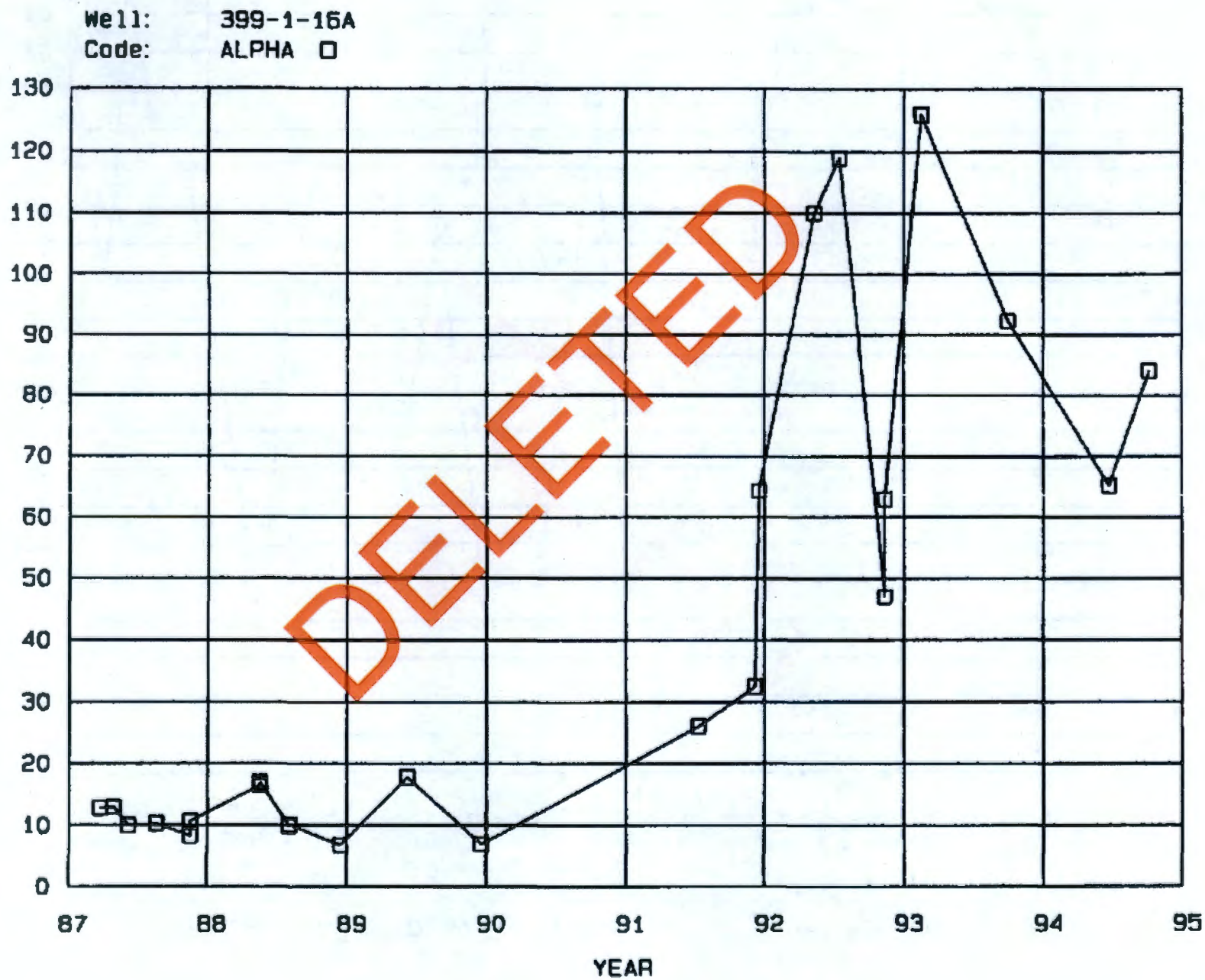
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



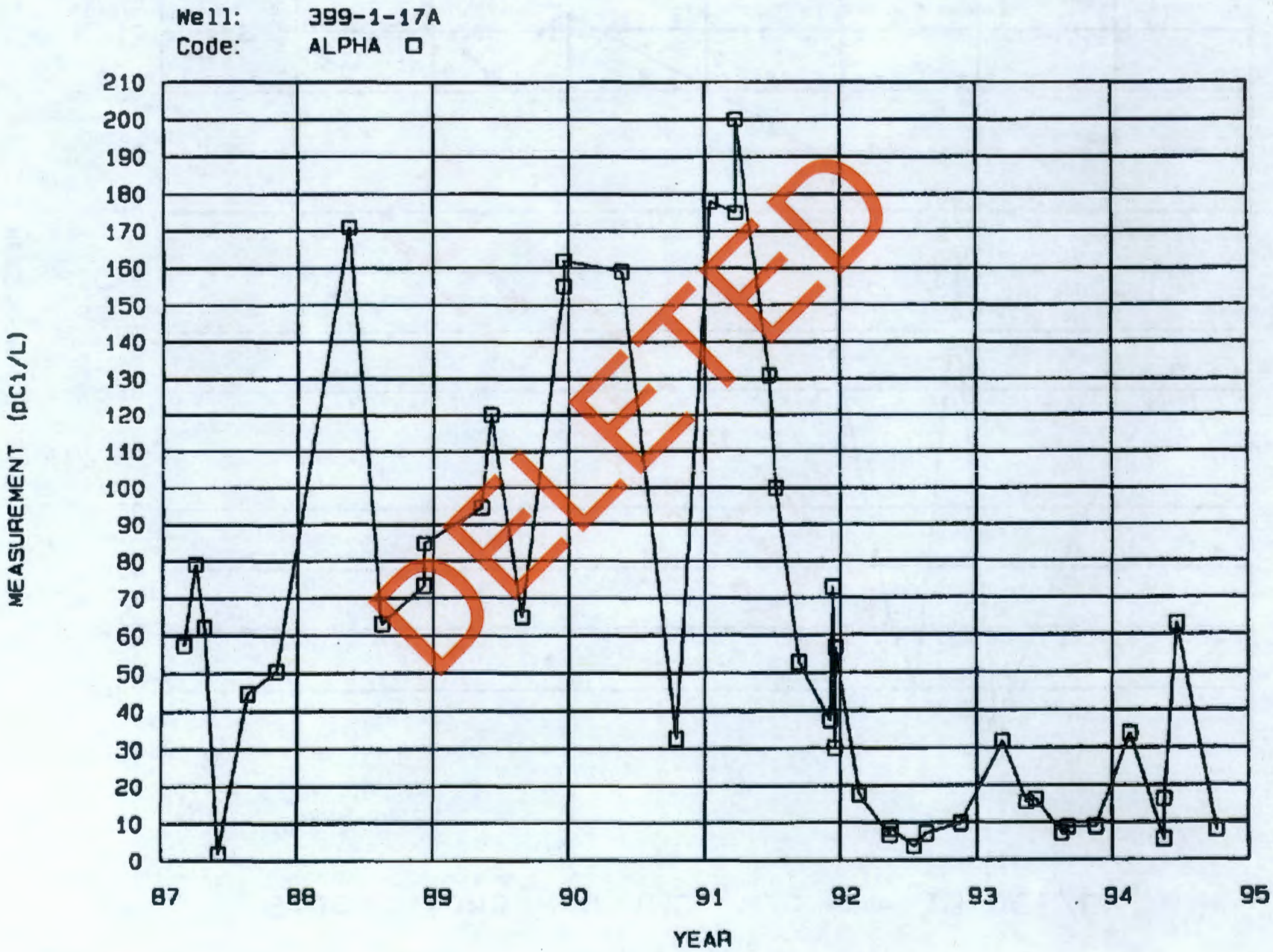
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



Gross Alpha w/U (MCL w/o U = 15 pCi/L)

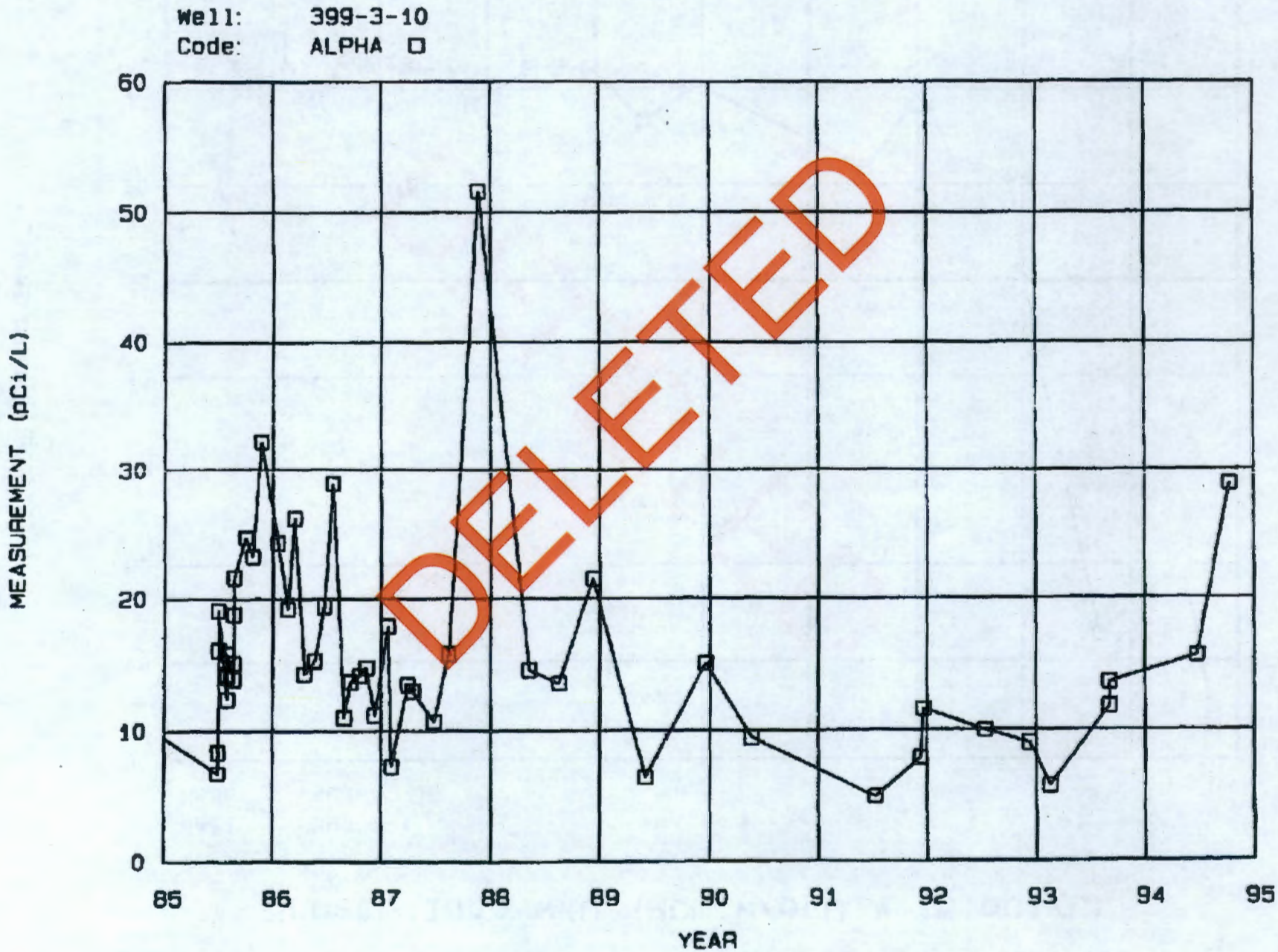


Gross Alpha w/U (MCL w/o U = 15 pCi/L)

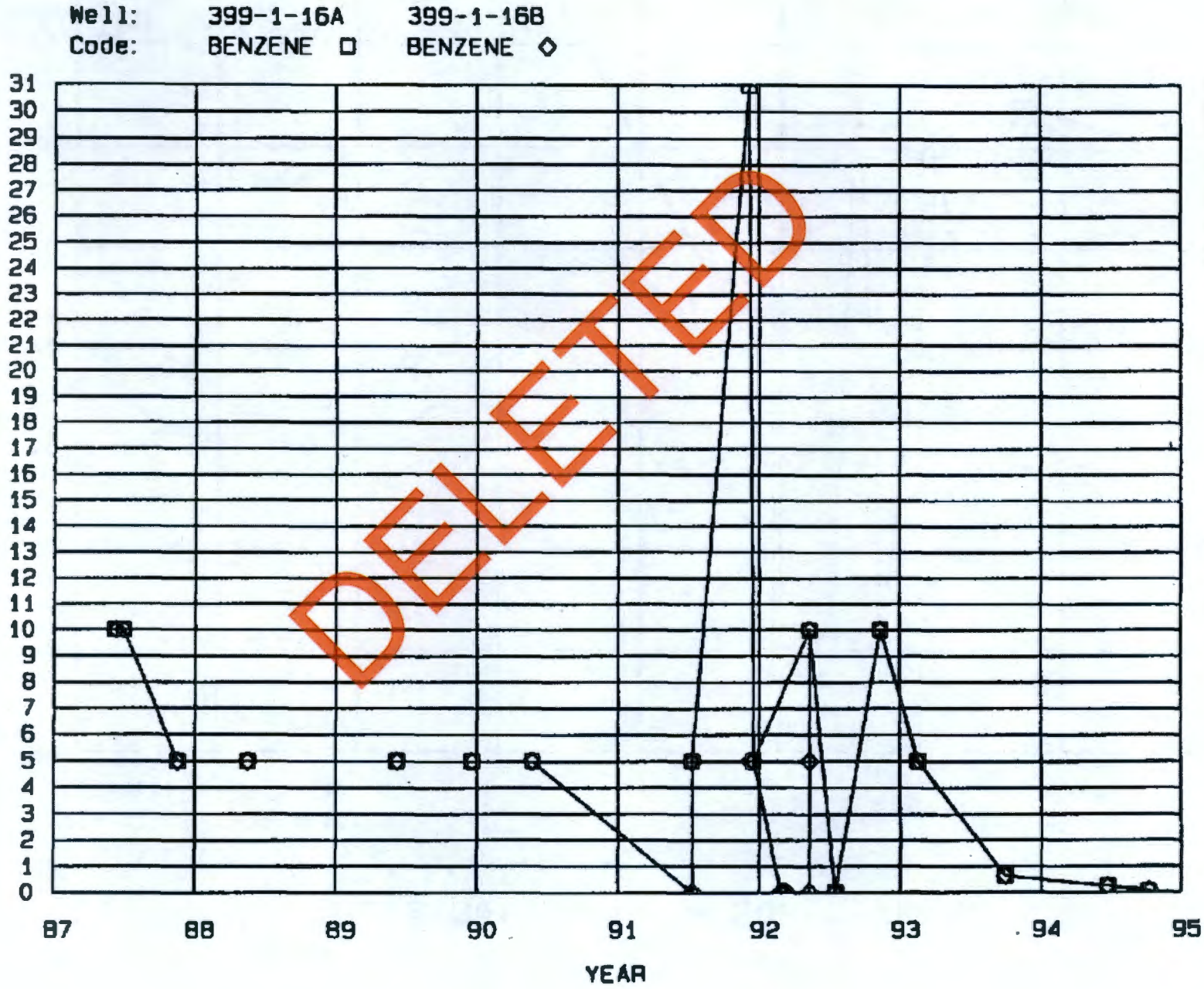


Gross Alpha w/U (MCL w/o U = 15 pCi/L)

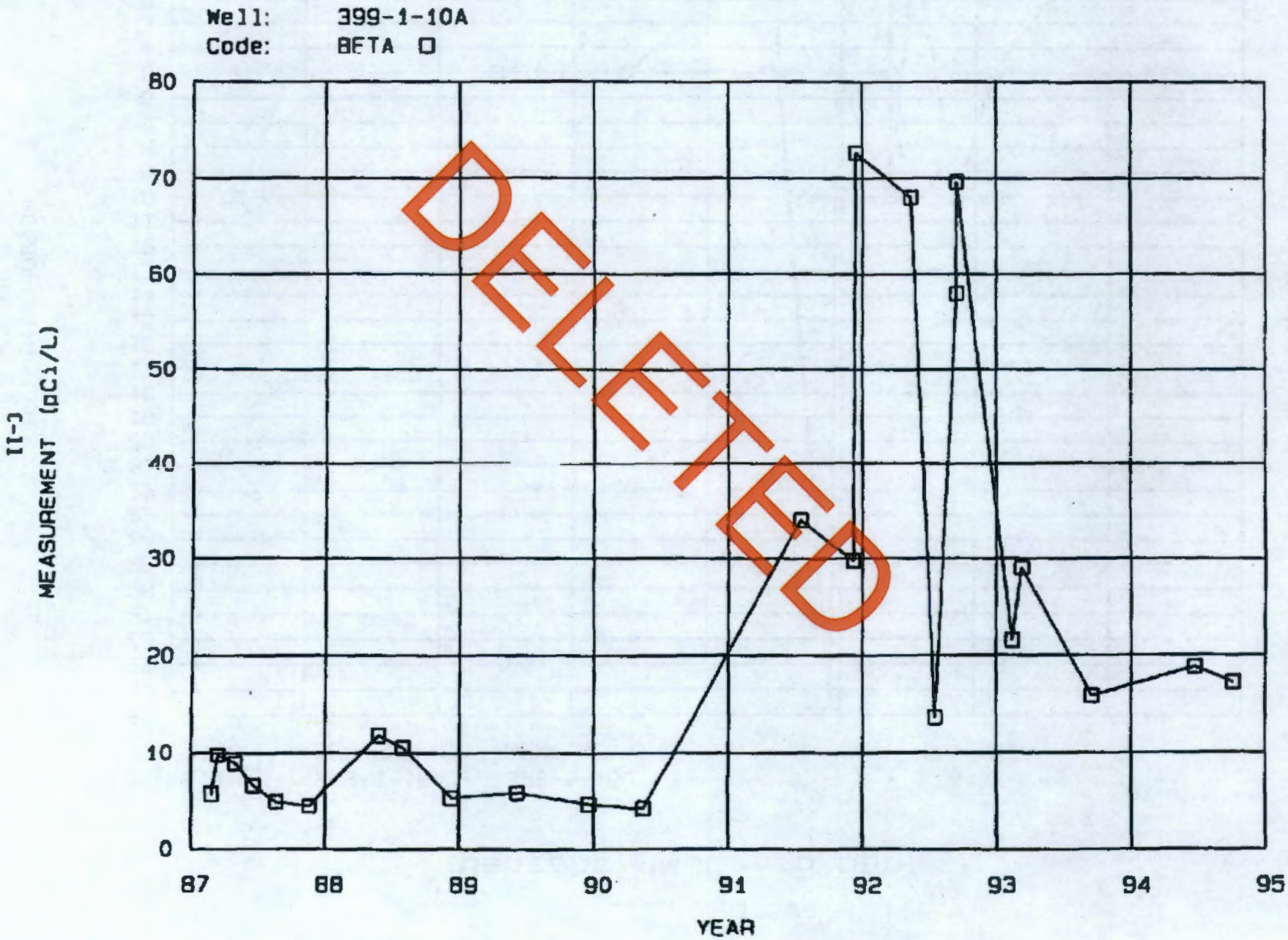
Gross Alpha w/U (MCL w/o U = 15 pCi/L)



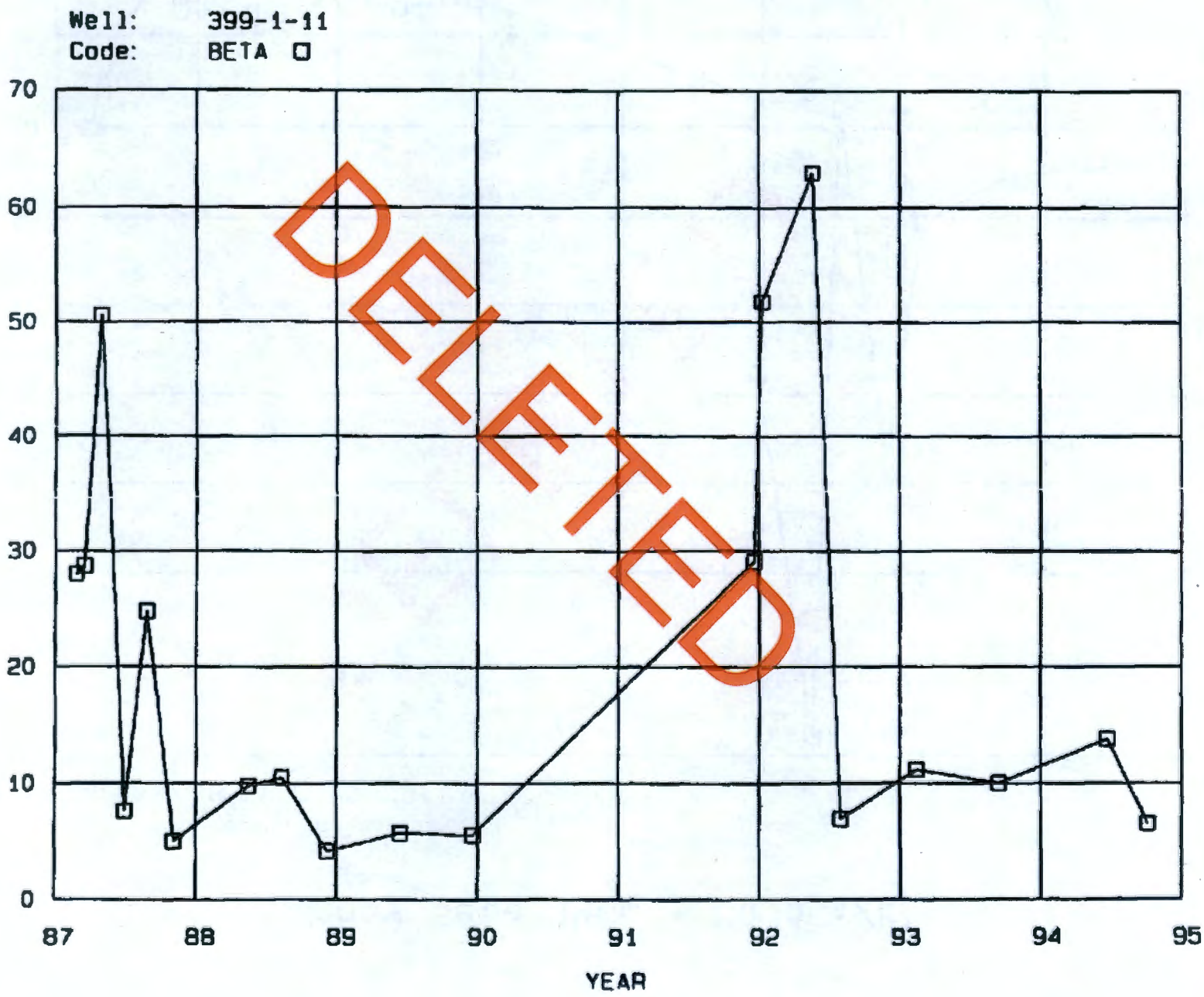
Benzene (MCL = 5 ppb)



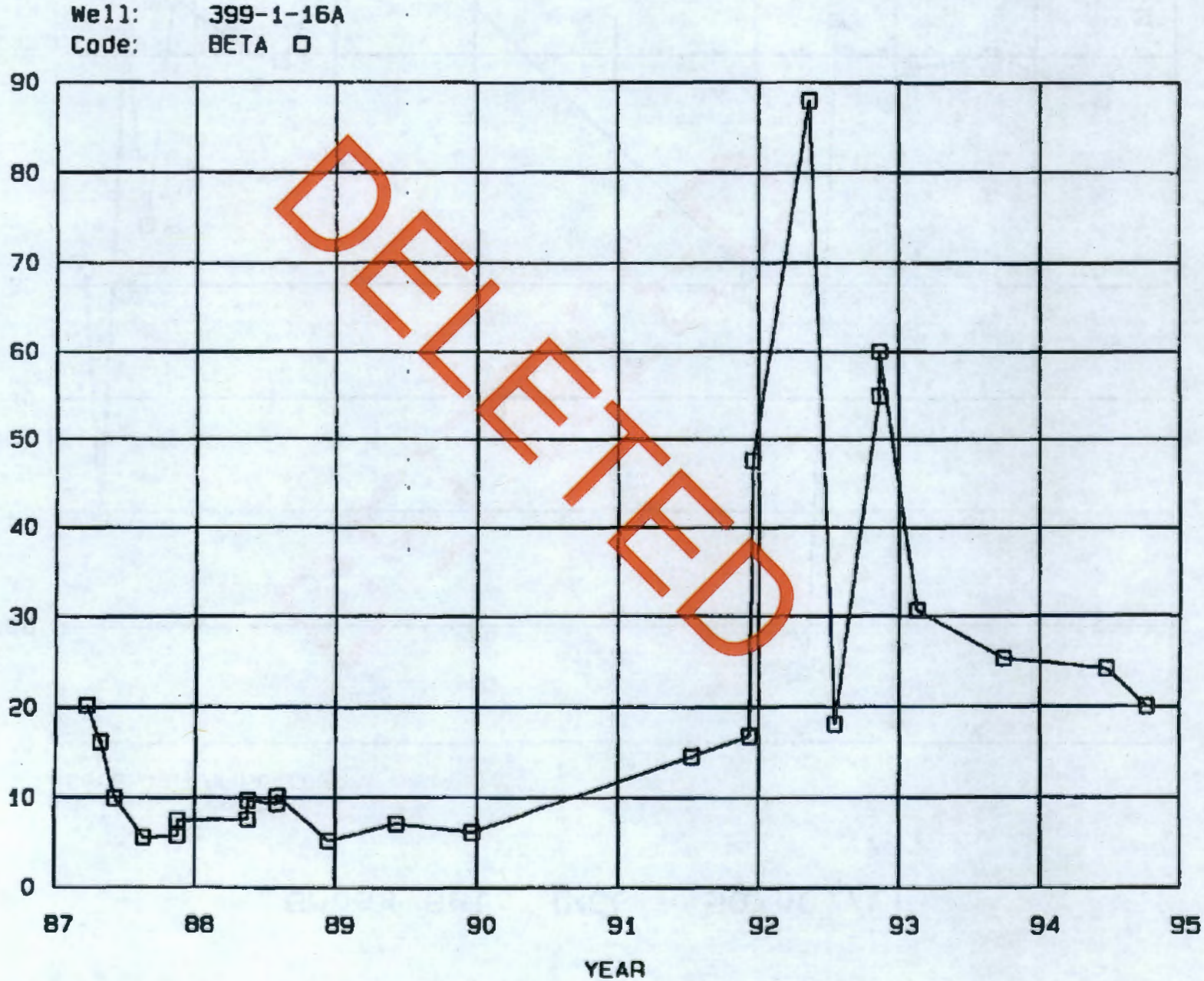
Gross Beta (MCL = 50 pCi/L)



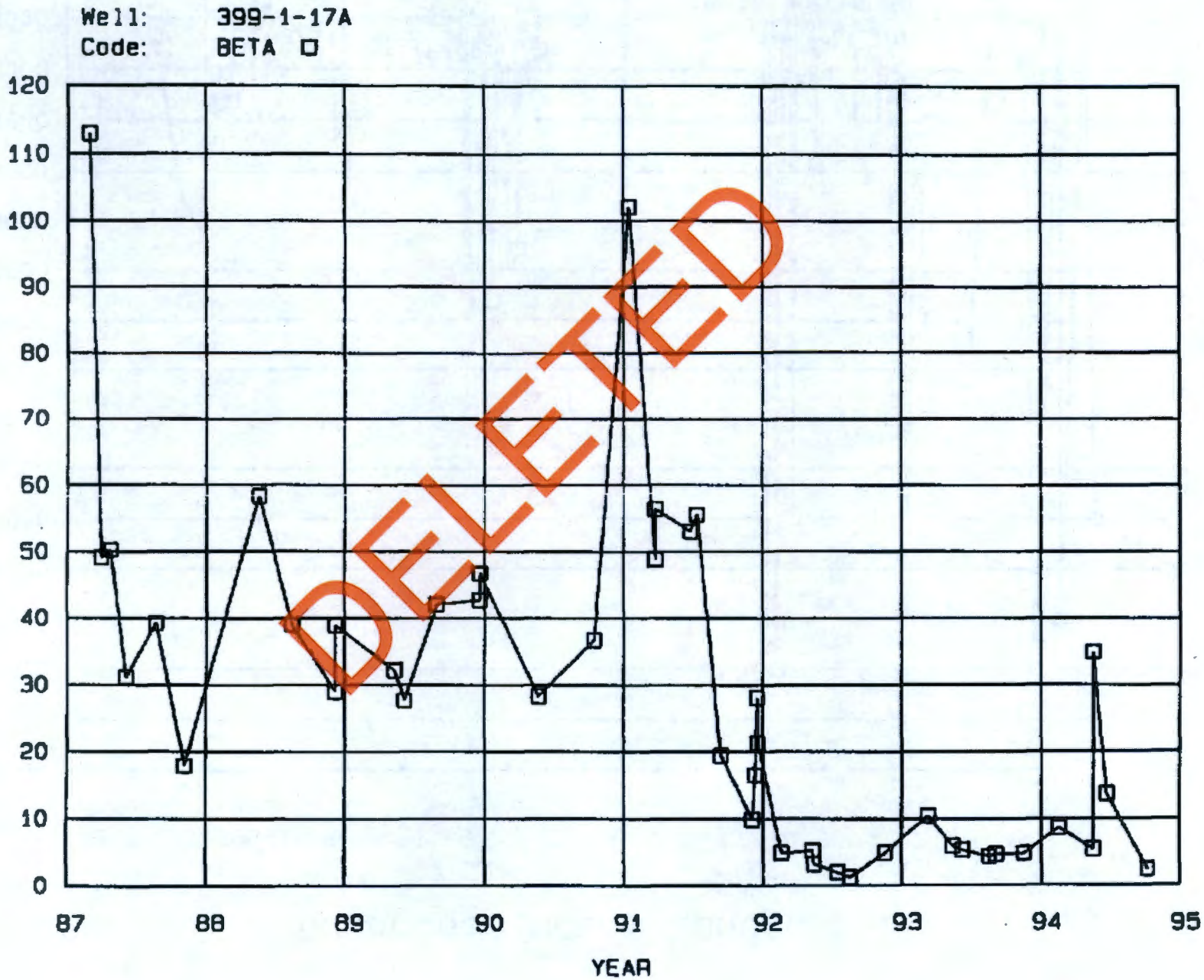
Gross Beta (MCL = 50 pCi/L)



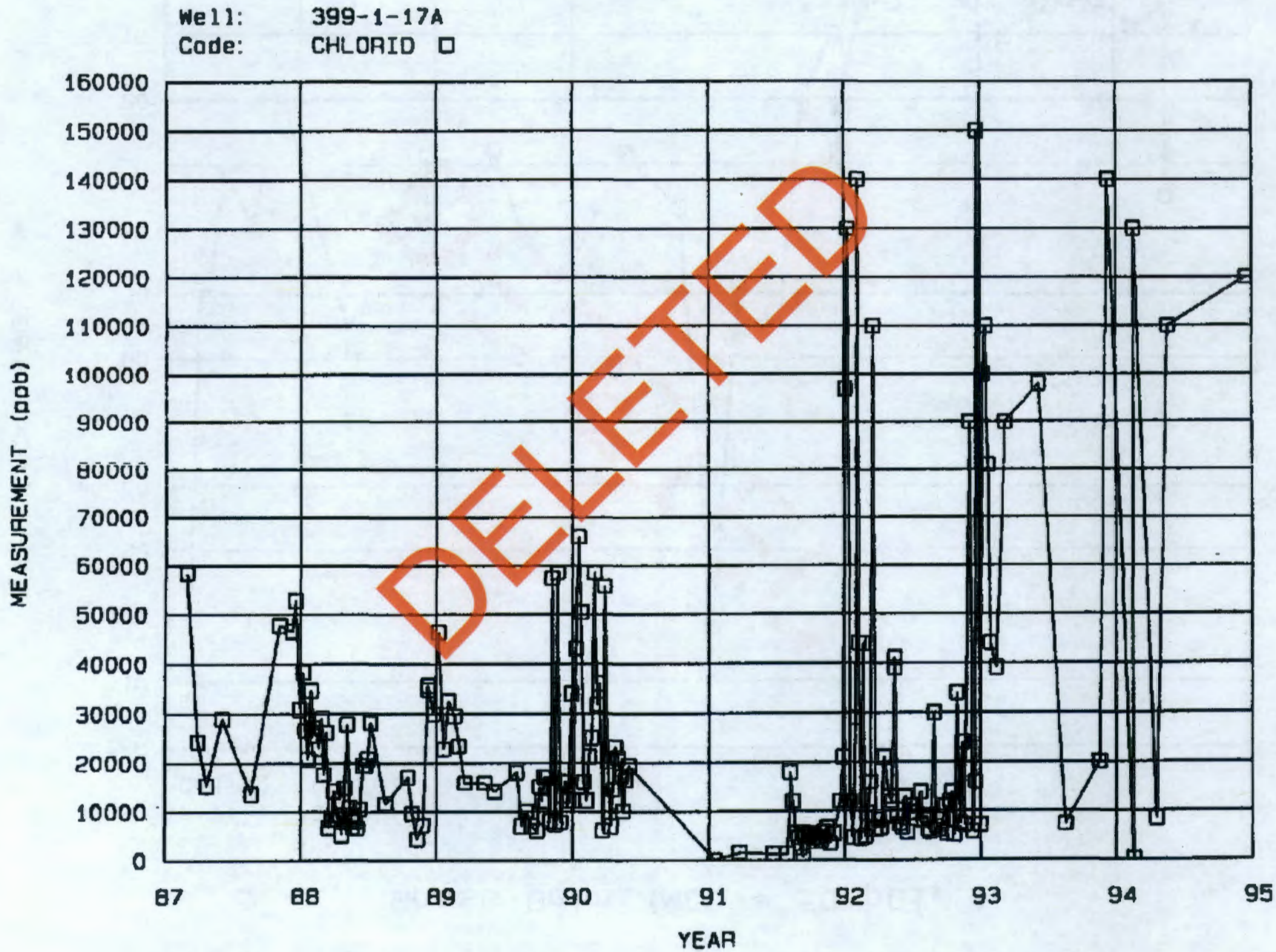
Gross Beta (MCL = 50 pCi/L)



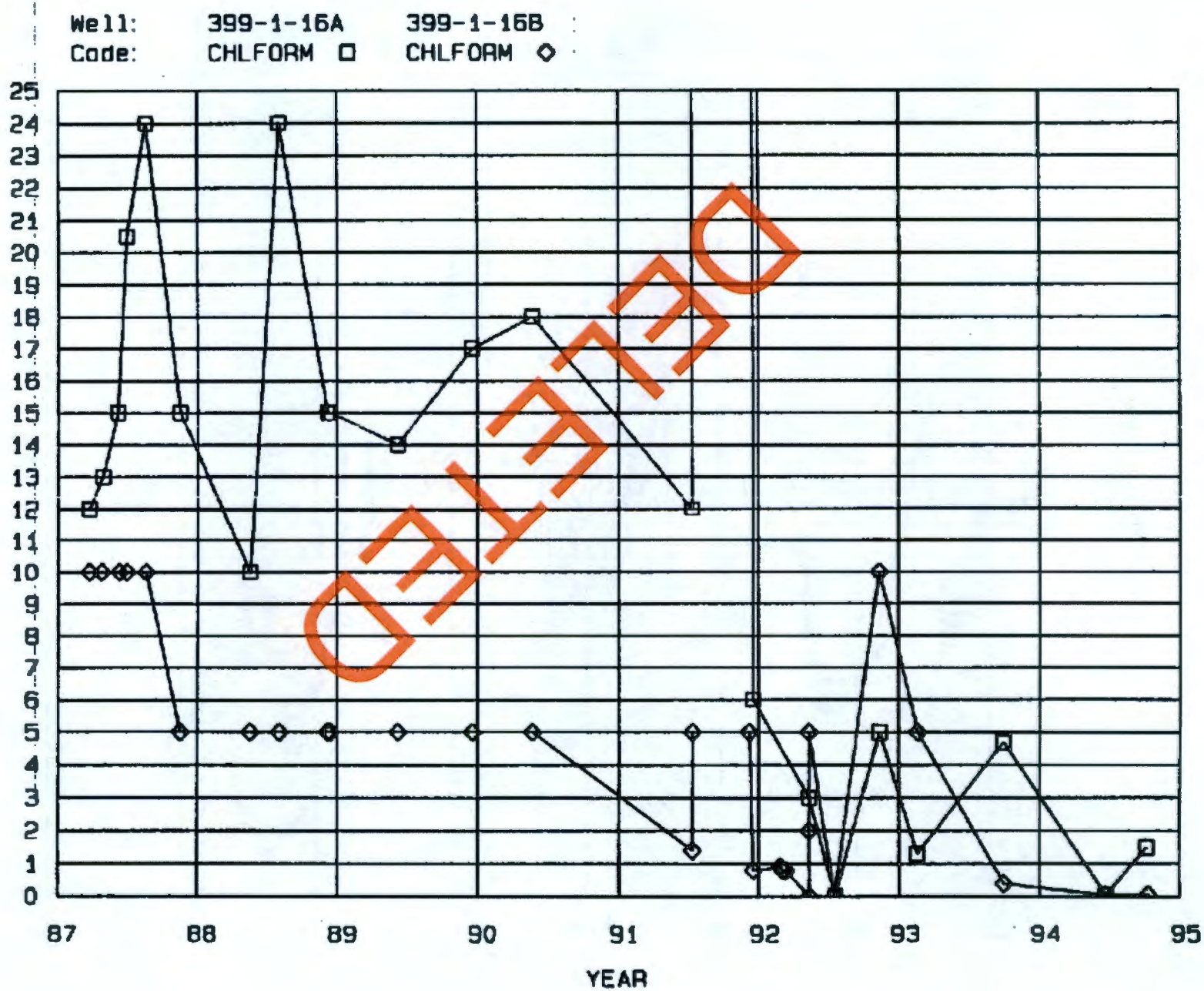
Gross Beta (MCL = 50 pCi/L)



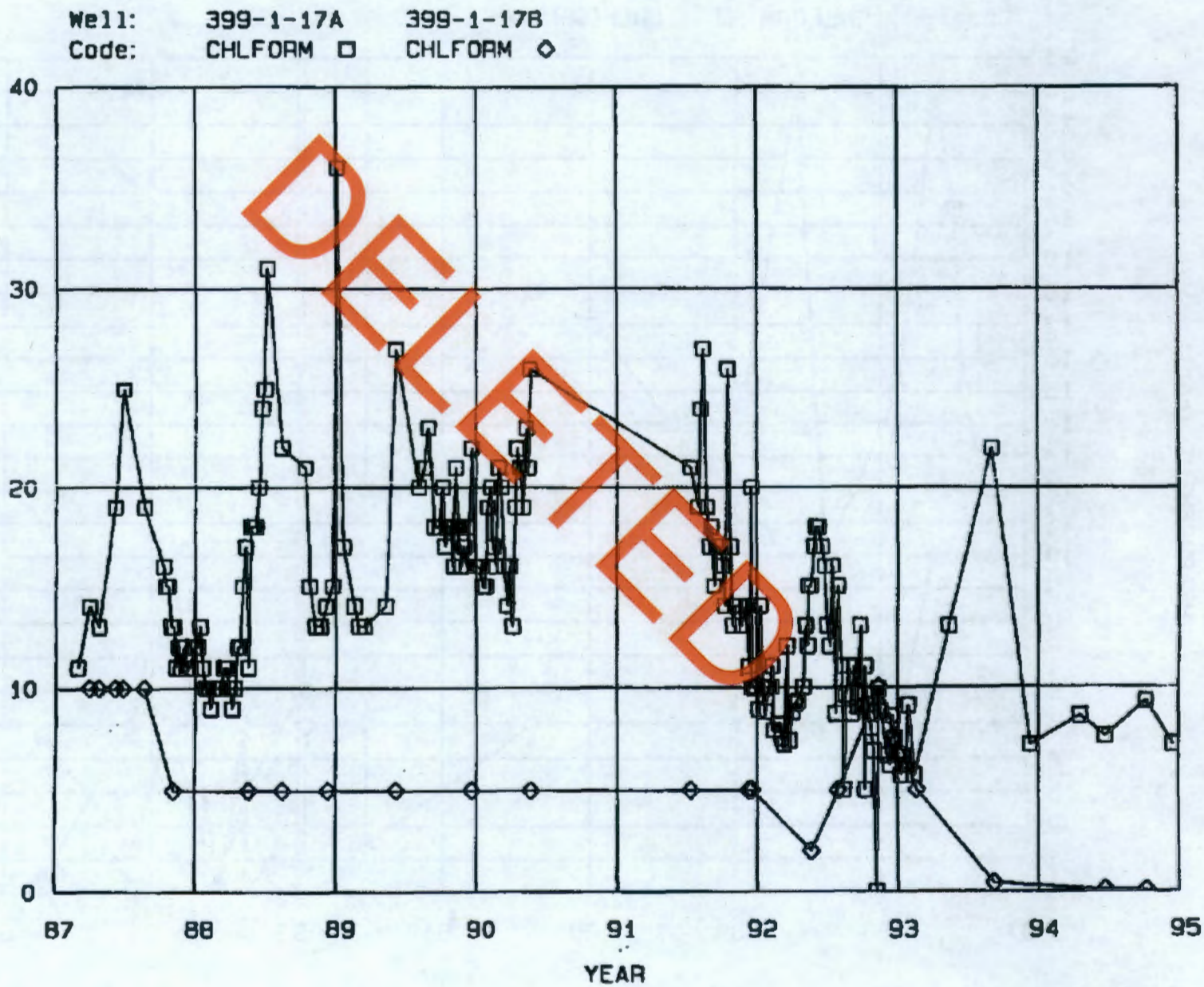
Chloride (MCL = 250000 ppb)



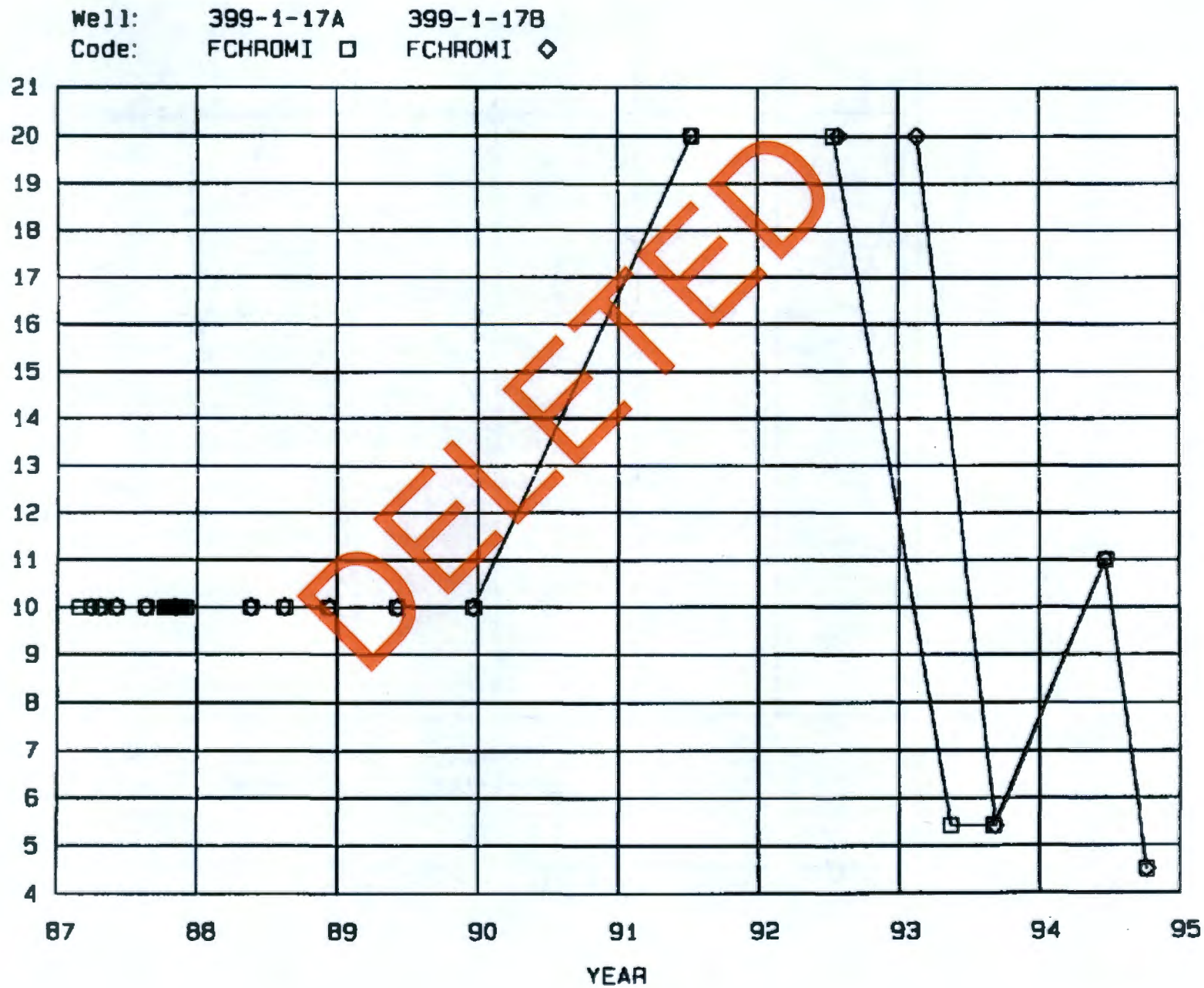
Chloroform


Well: 399-1-16A 399-1-16B
Code: CHLFORM CHLFORM
MEASUREMENT (ppb)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
87 88 89 90 91 92 93 94 95
YEAR
DELETED

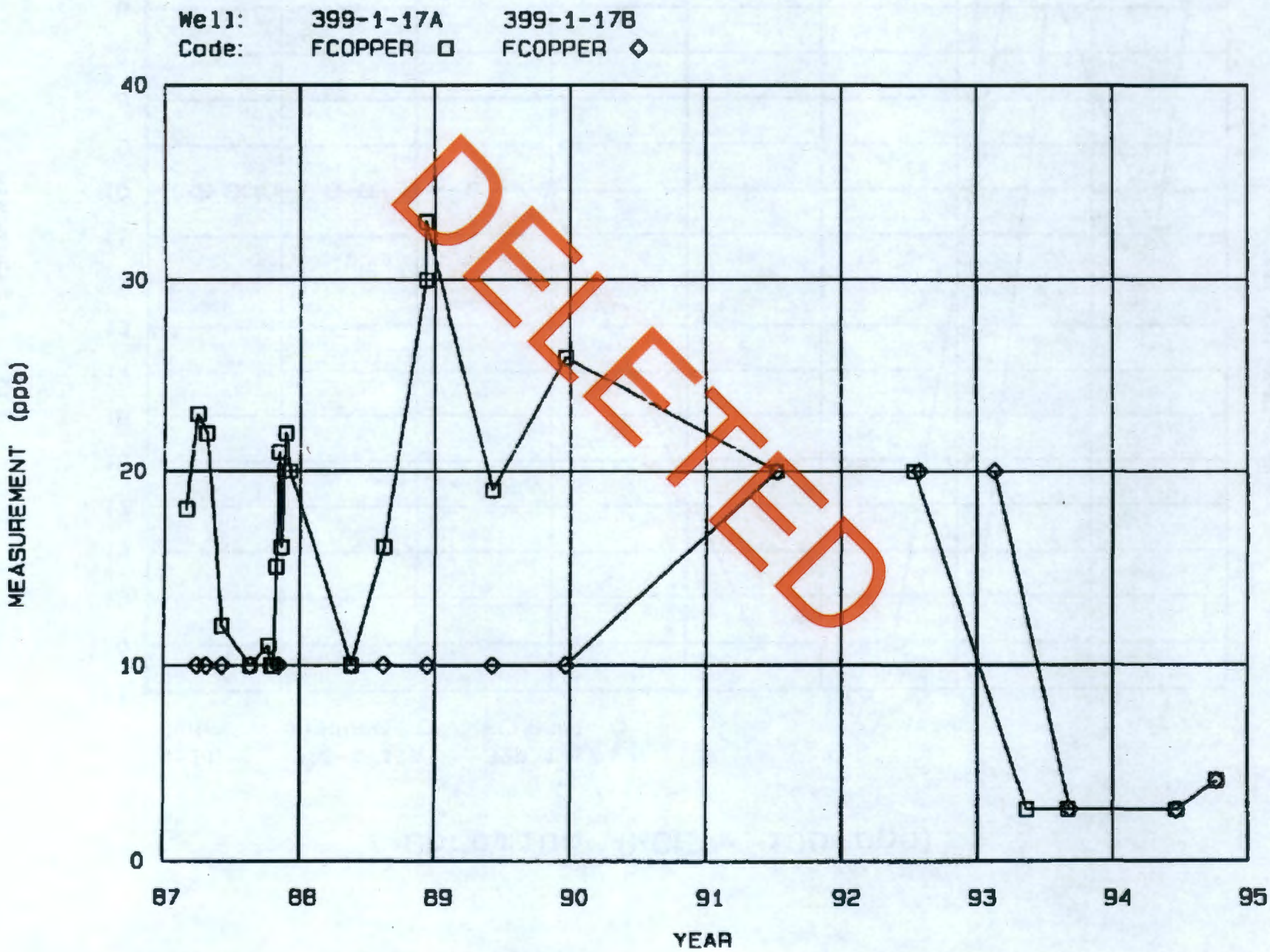
Chloroform


Well: 399-1-17A 399-1-17B
Code: CHLFORM □ CHLFORM ◇
40
30
20
10
0
MEASUREMENT (ppb)
87
88
89
90
91
92
93
94
95
YEAR
DELETED

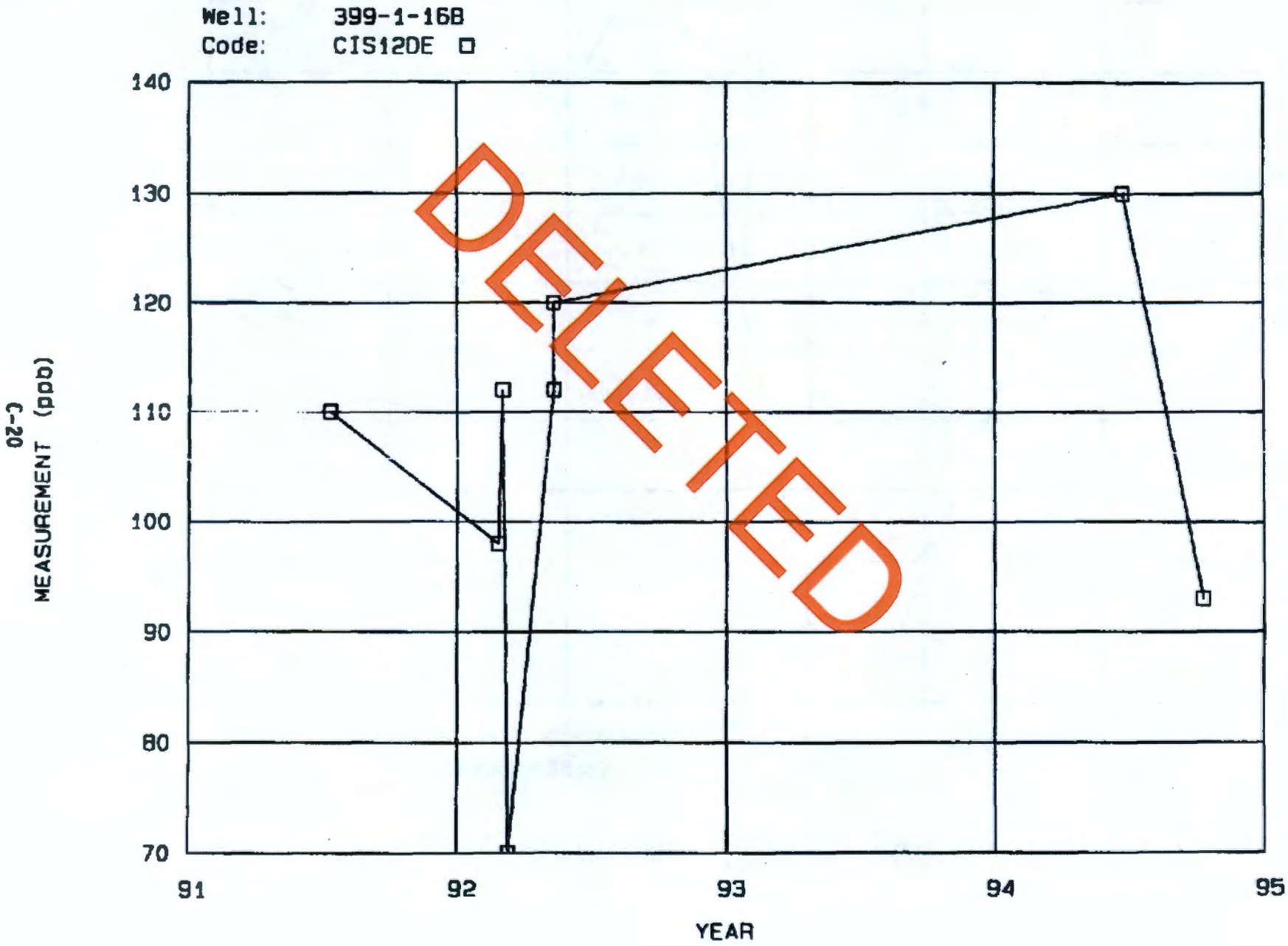
Chromium (MCL = 100 ppb)



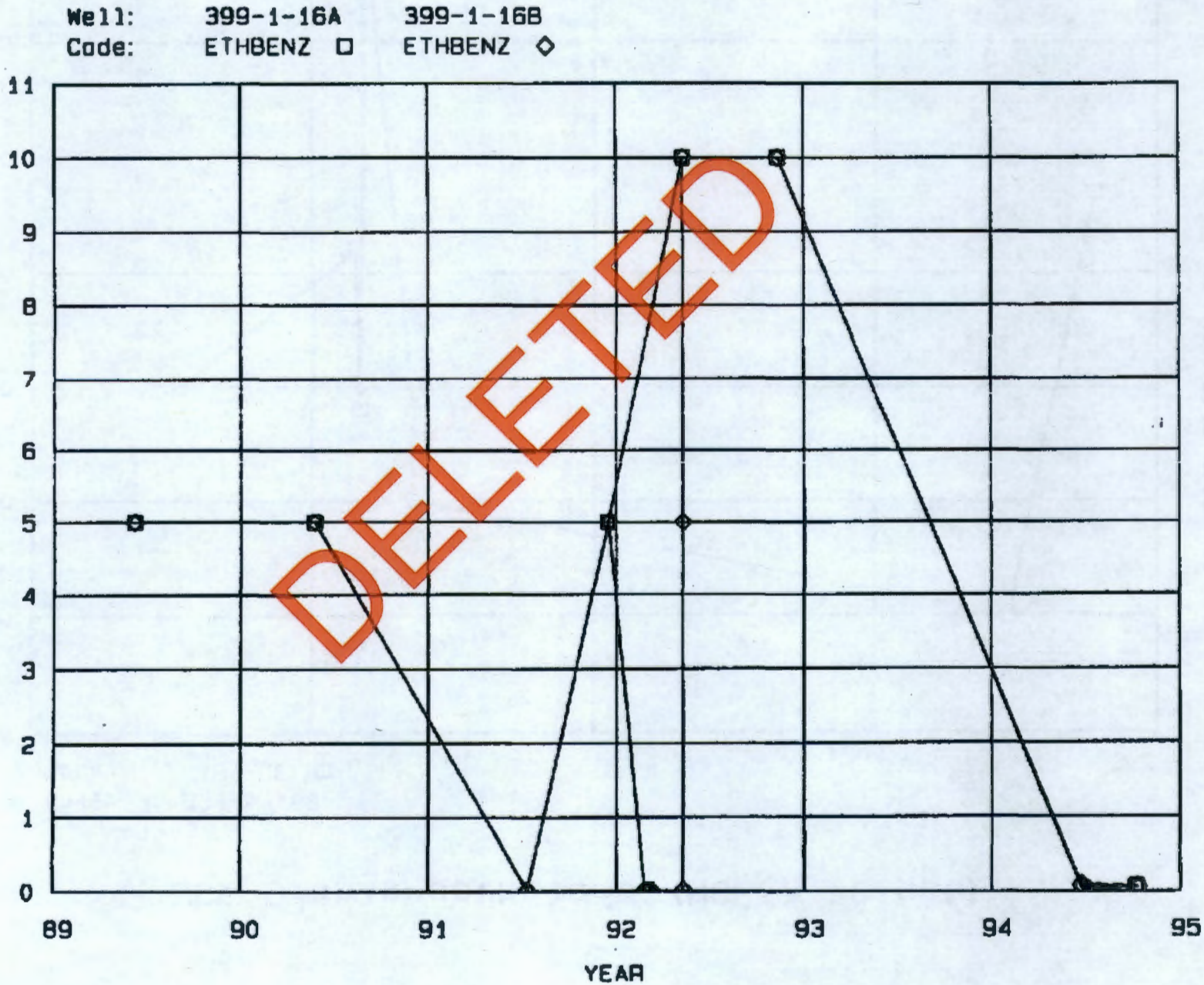
Copper (MCL = 1000 ppb)



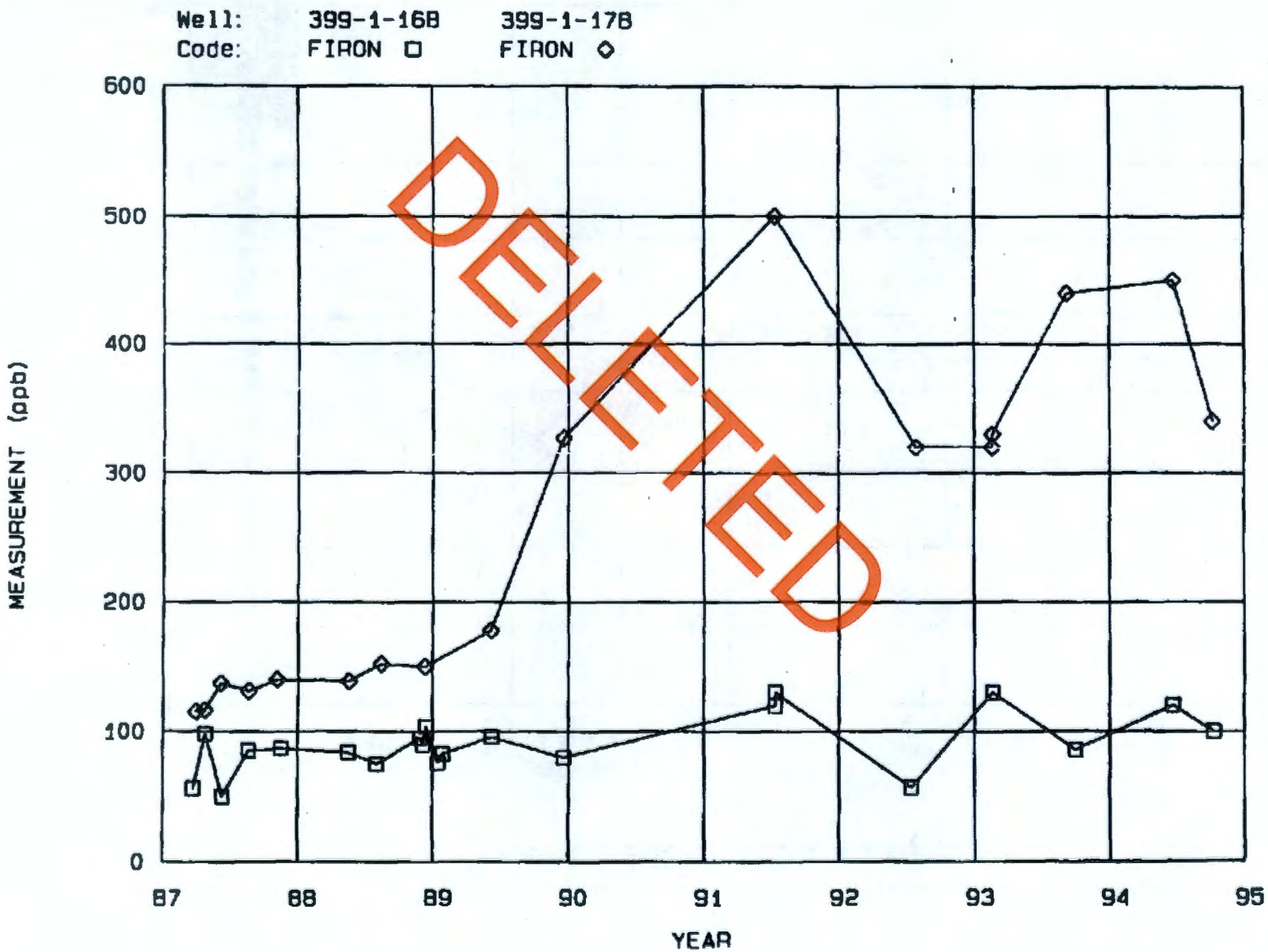
DCE Dichloroethylene (MCL = 70 ppb)



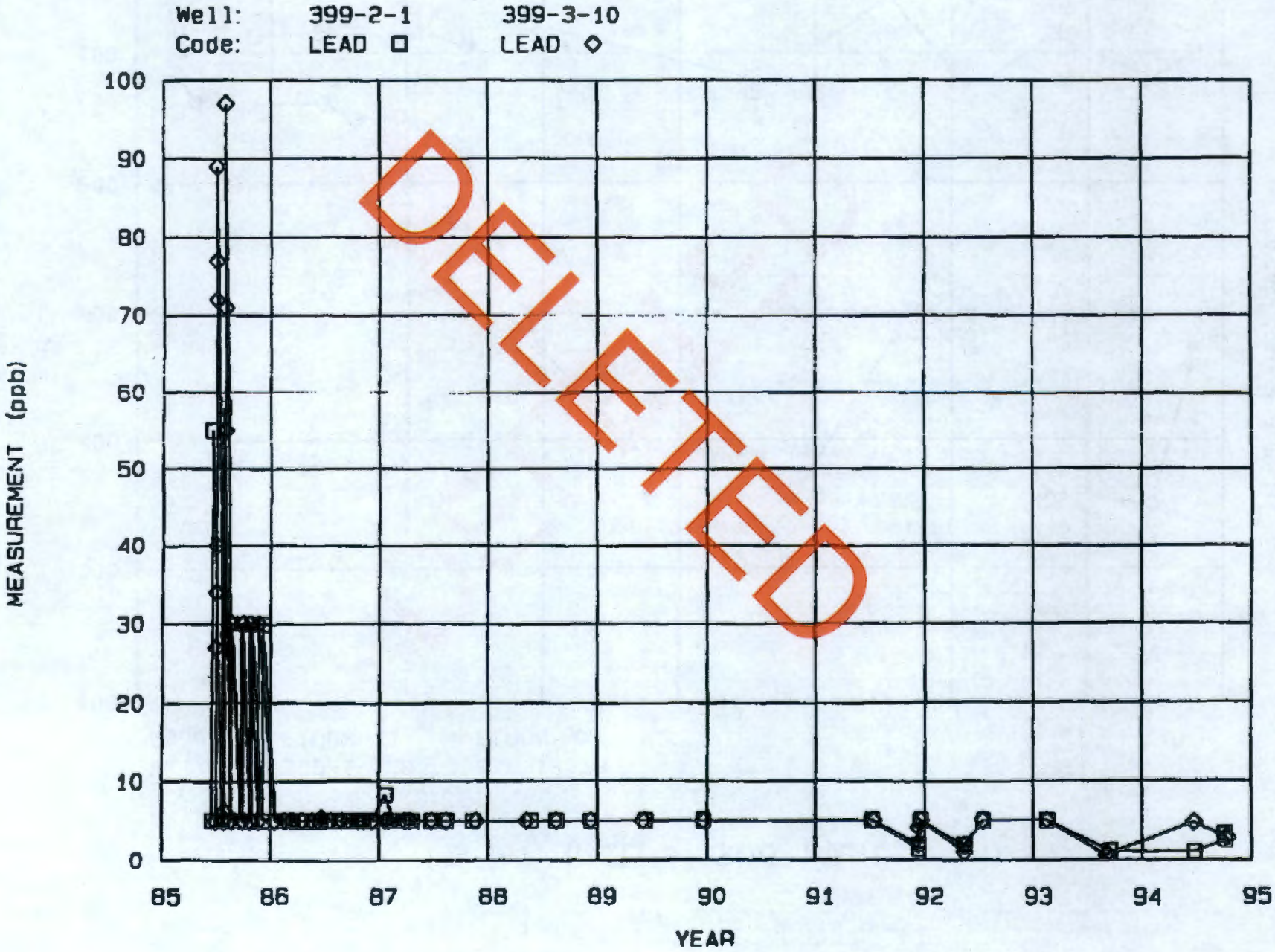
Ethylbenzene (MCL = 700 ppb)



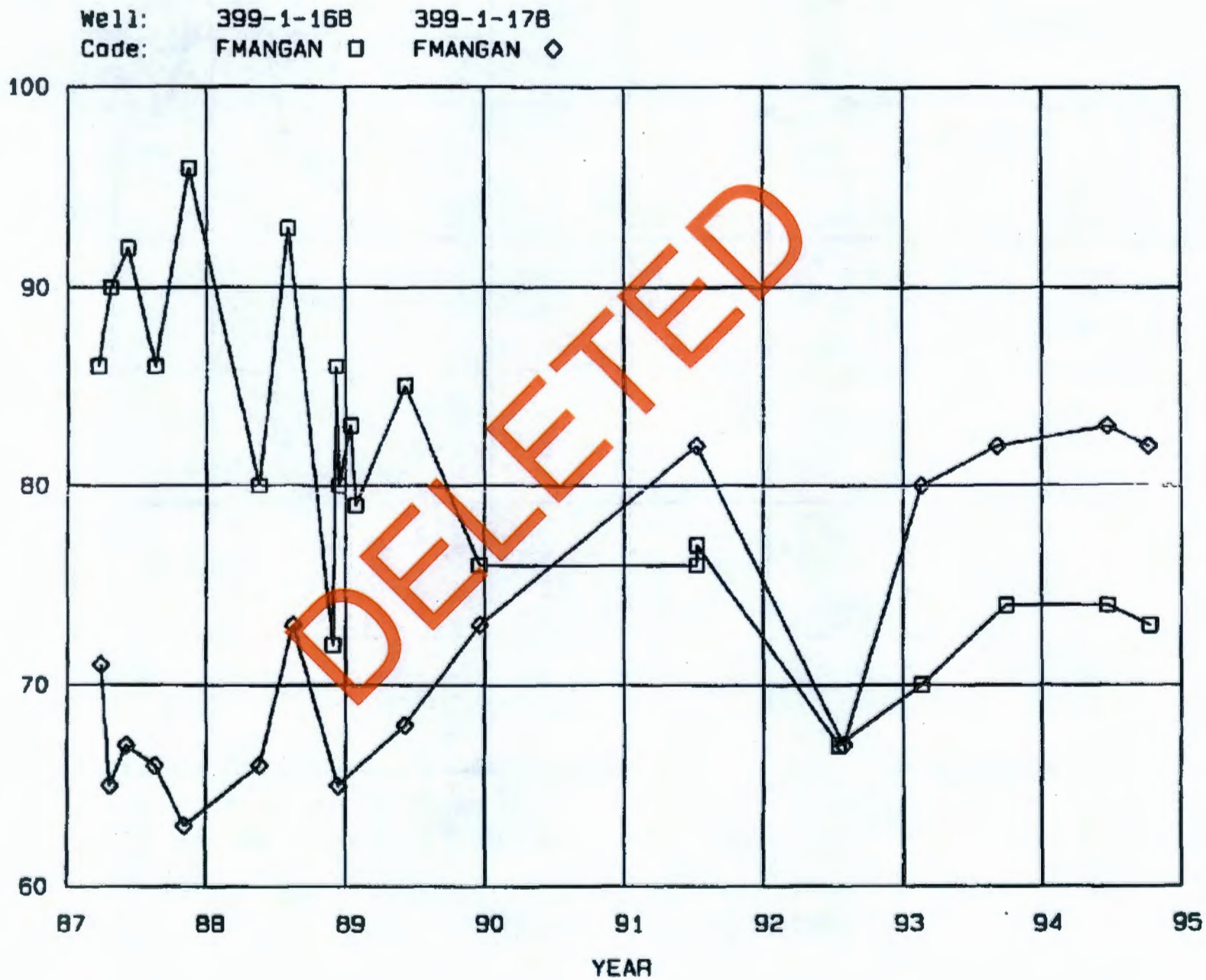
Iron (MCL = 300 ppb)



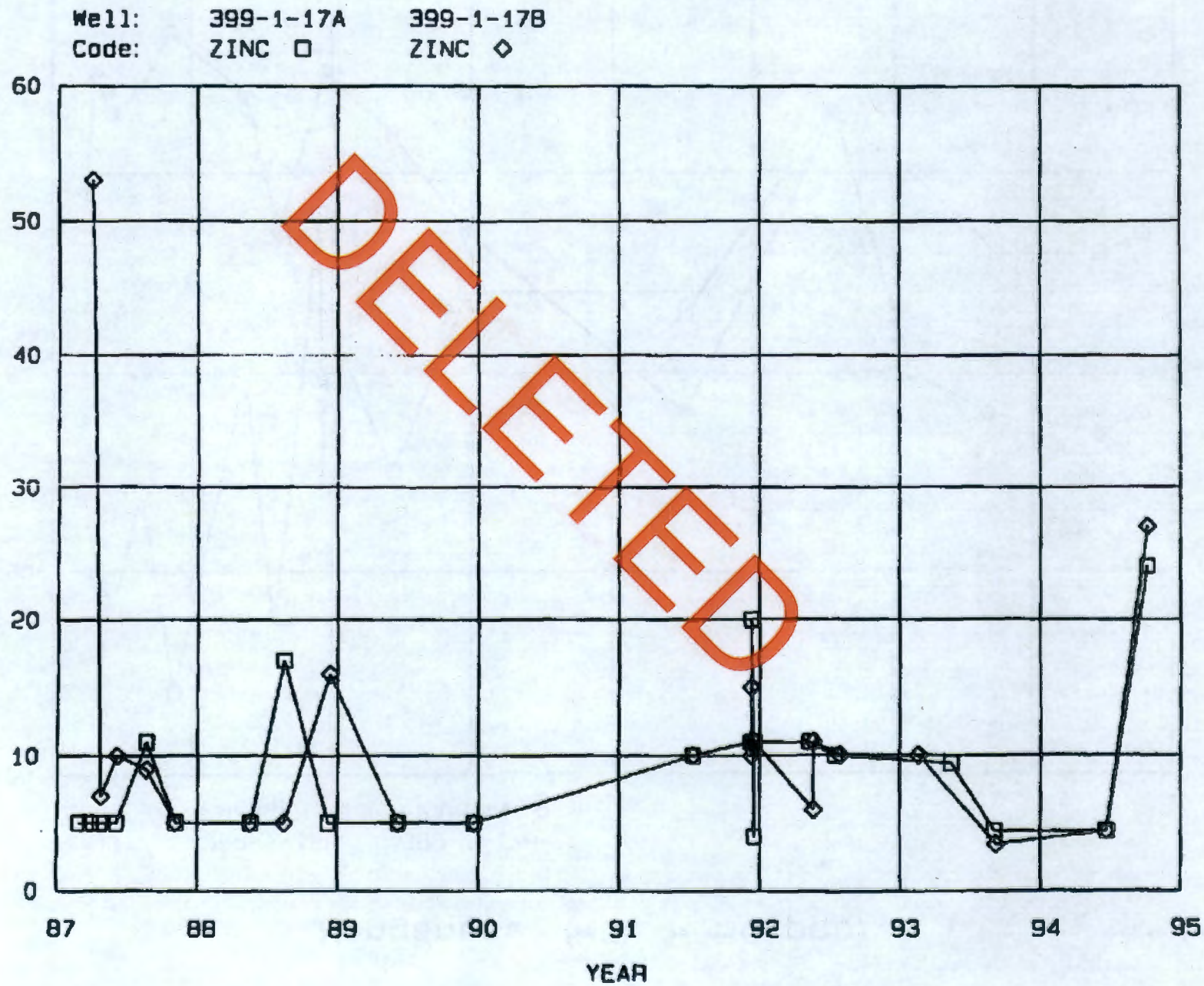
Lead (MCL = 50 ppb)



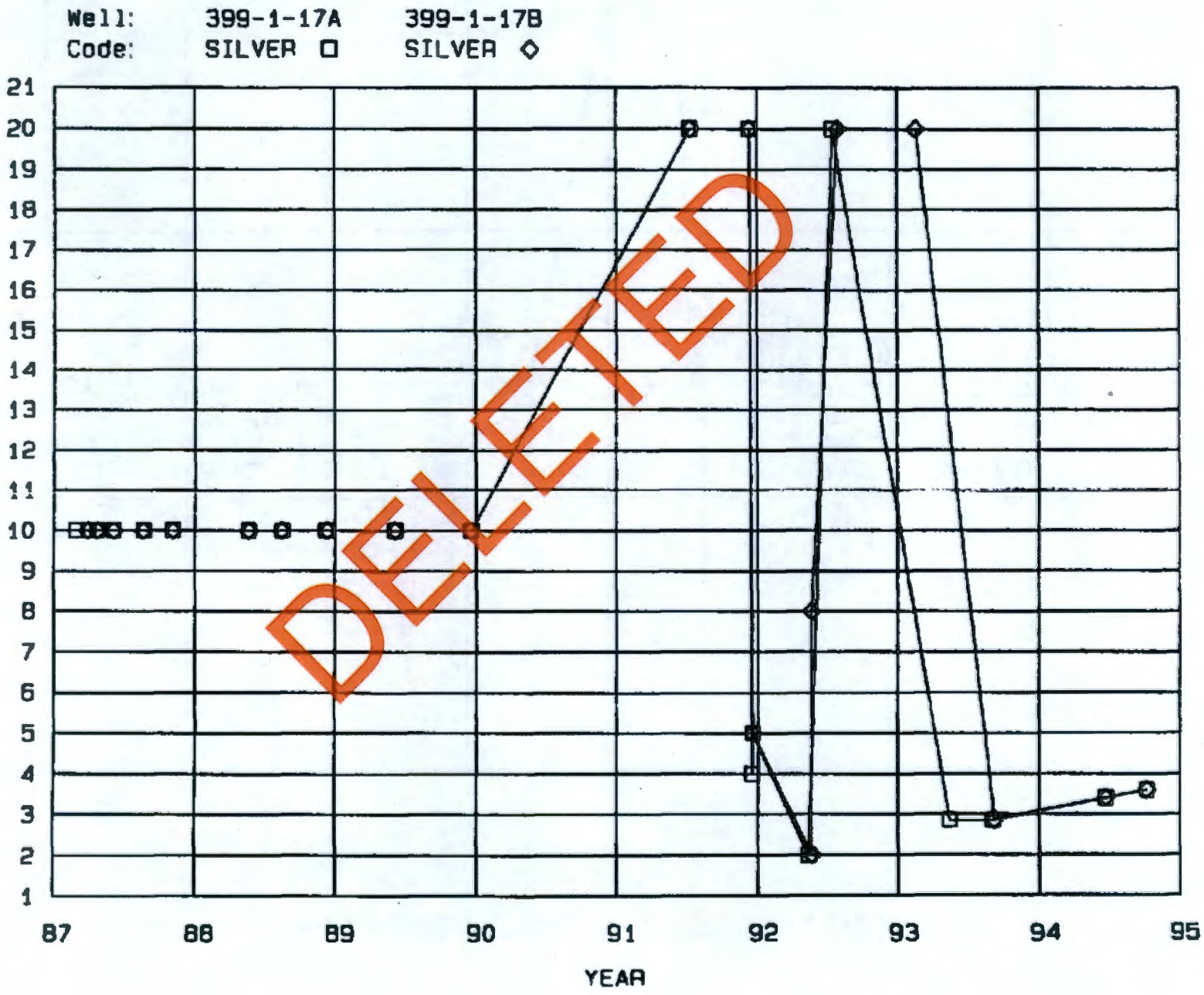
Manganese (MCL = 50 ppb)



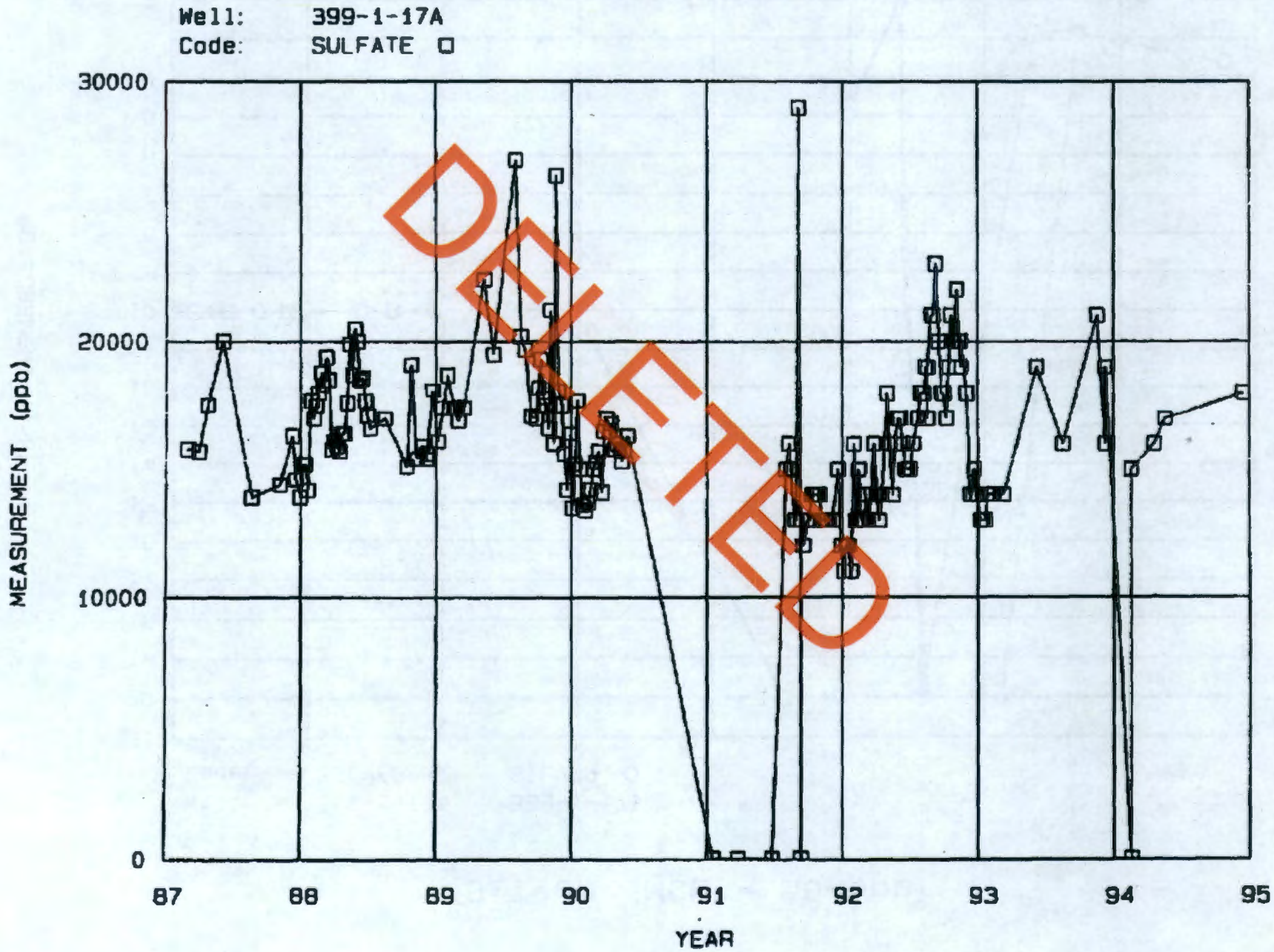
Zinc (MCL = 5000 ppb)



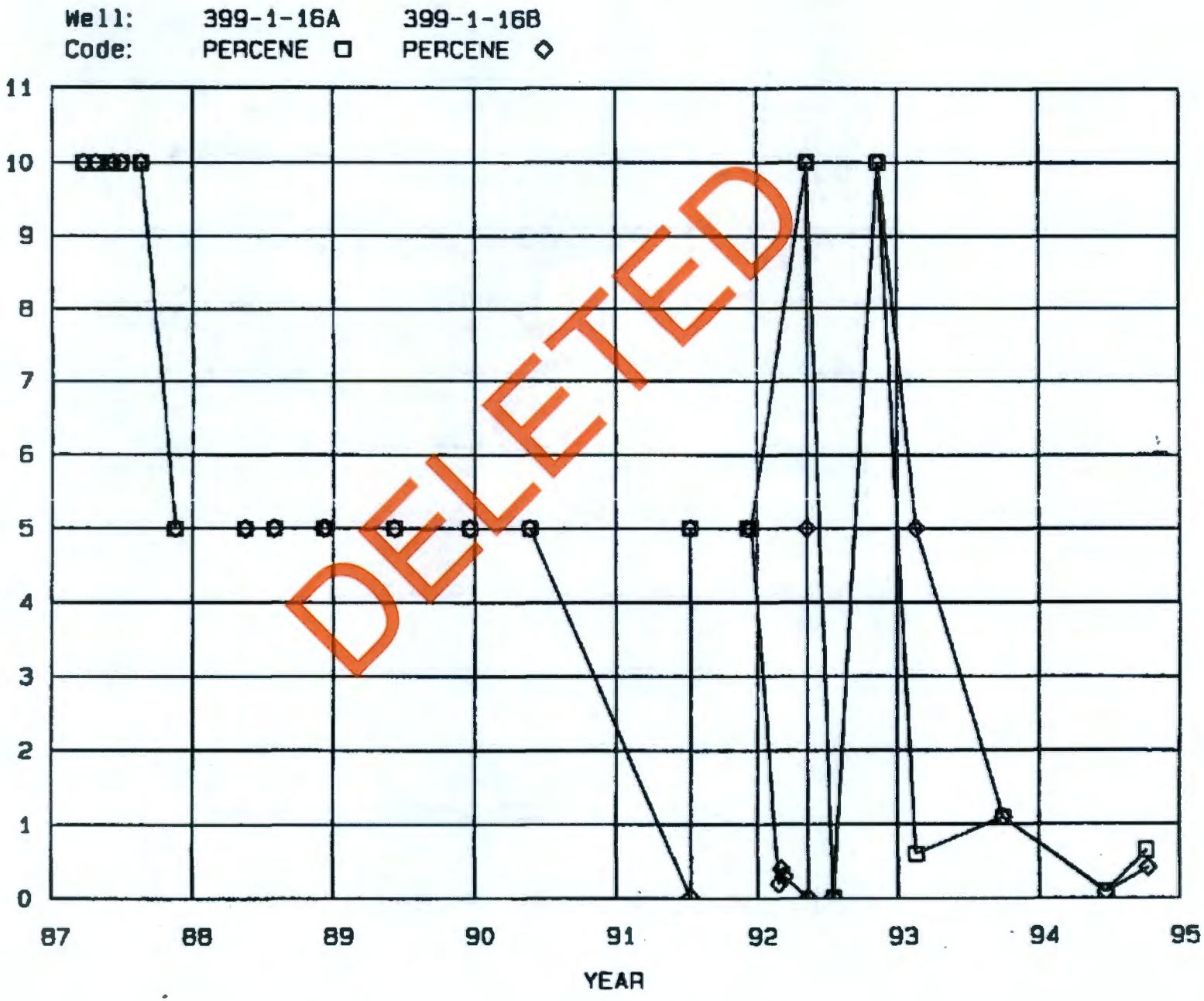
Silver (MCL = 50 ppb)



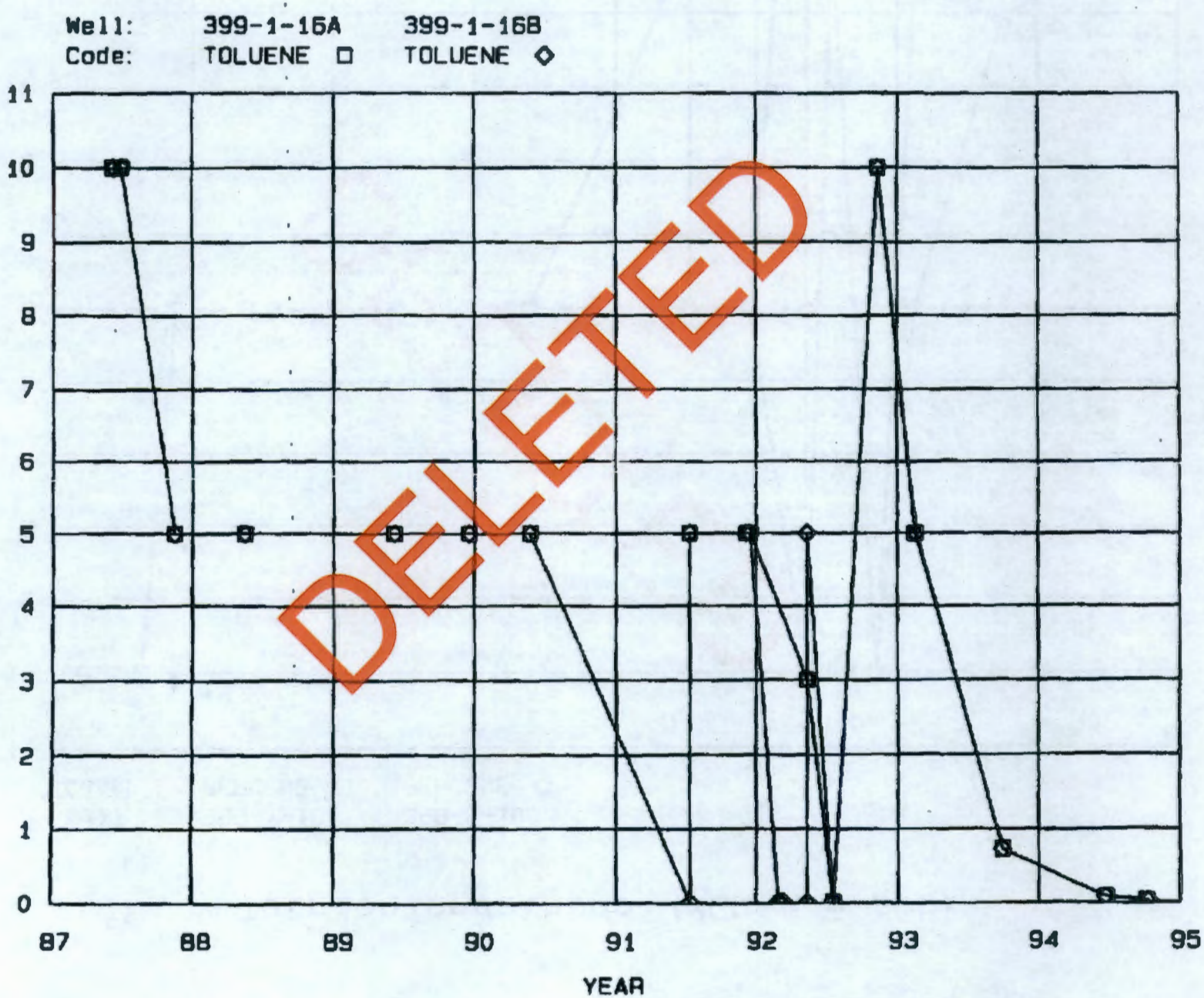
Sulfate (MCL = 250000 ppb)

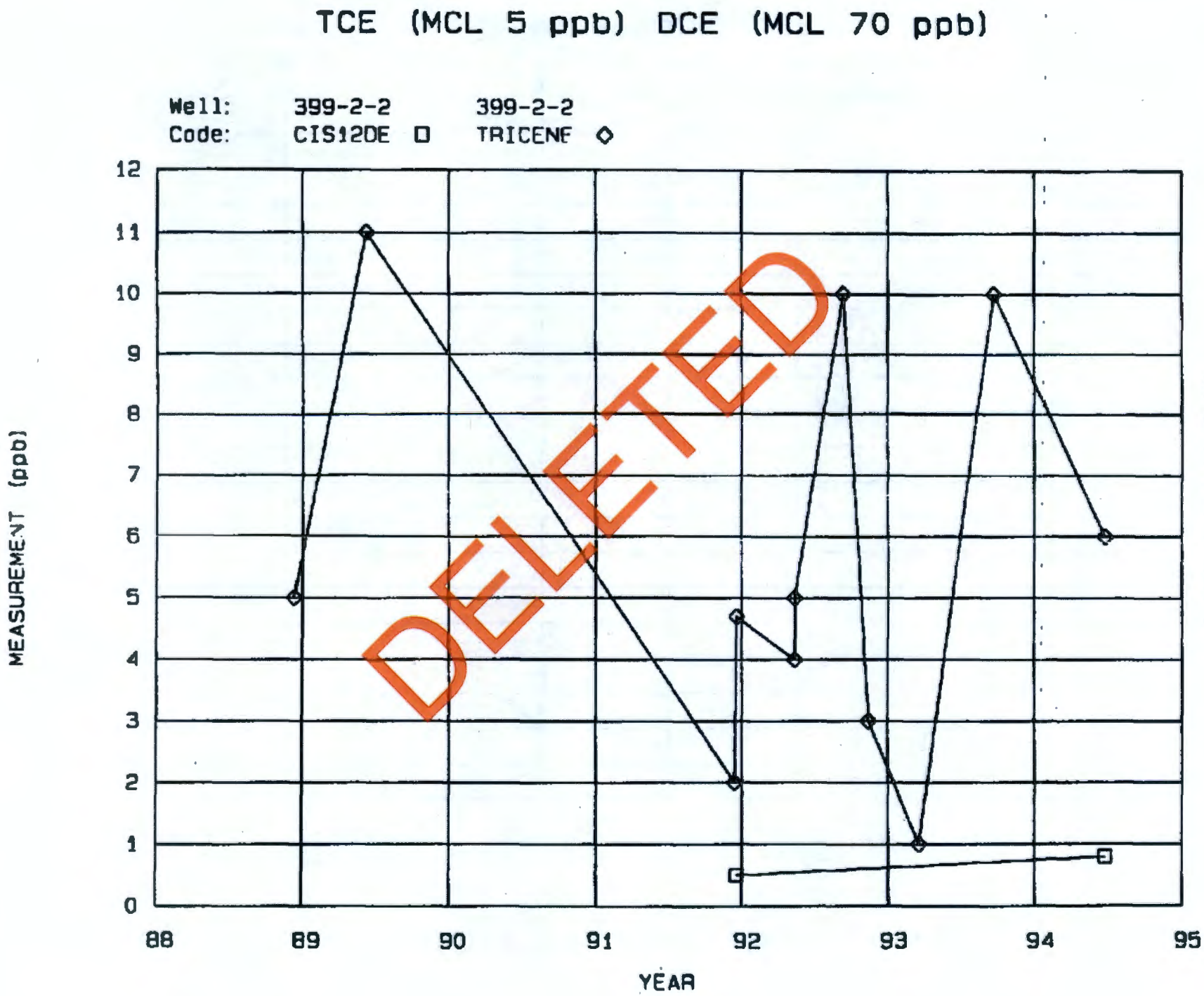


Tetrachloroethene (MCL = 5 ppb)

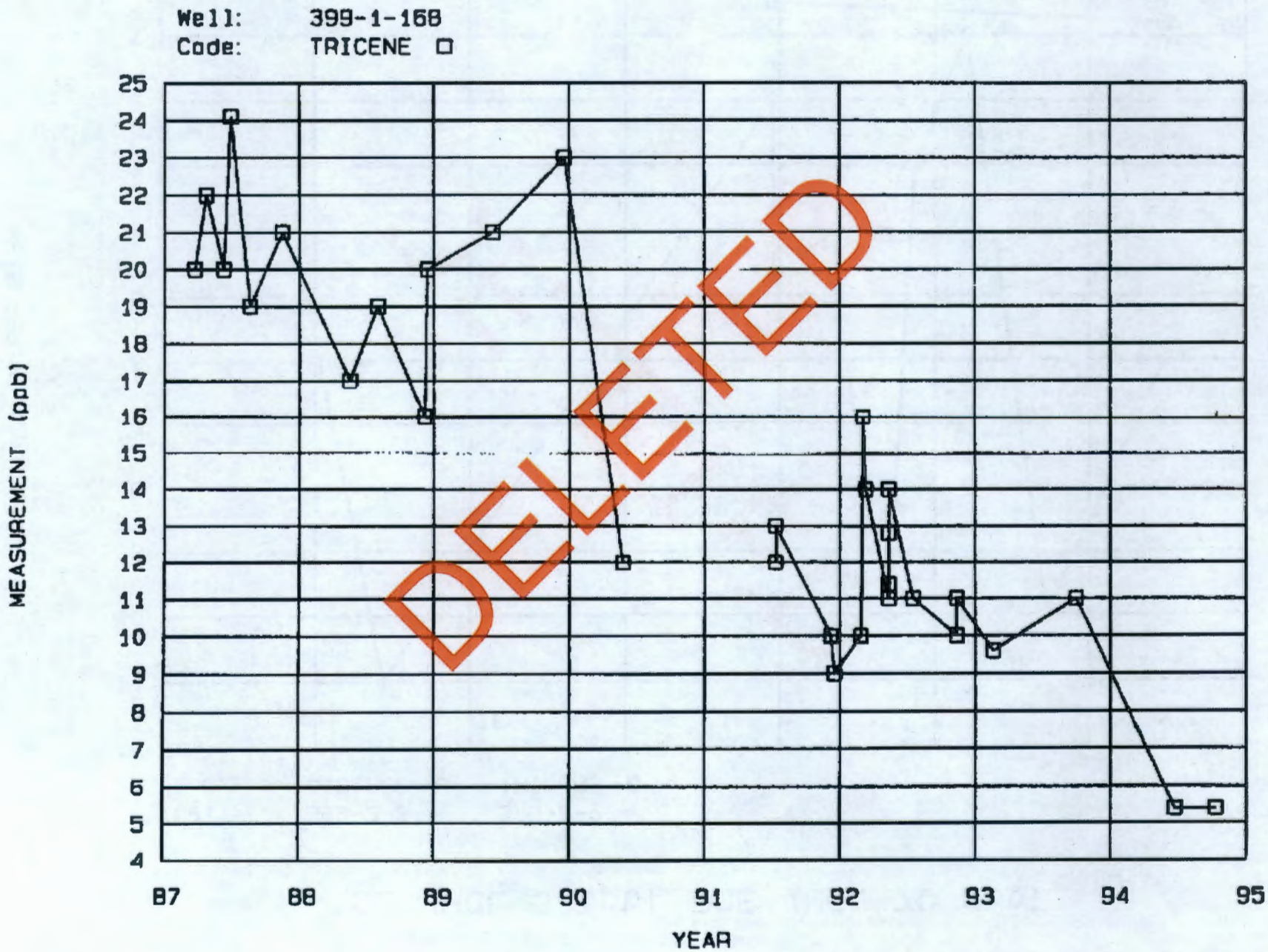


Toluene (MCL = 1000 ppb)

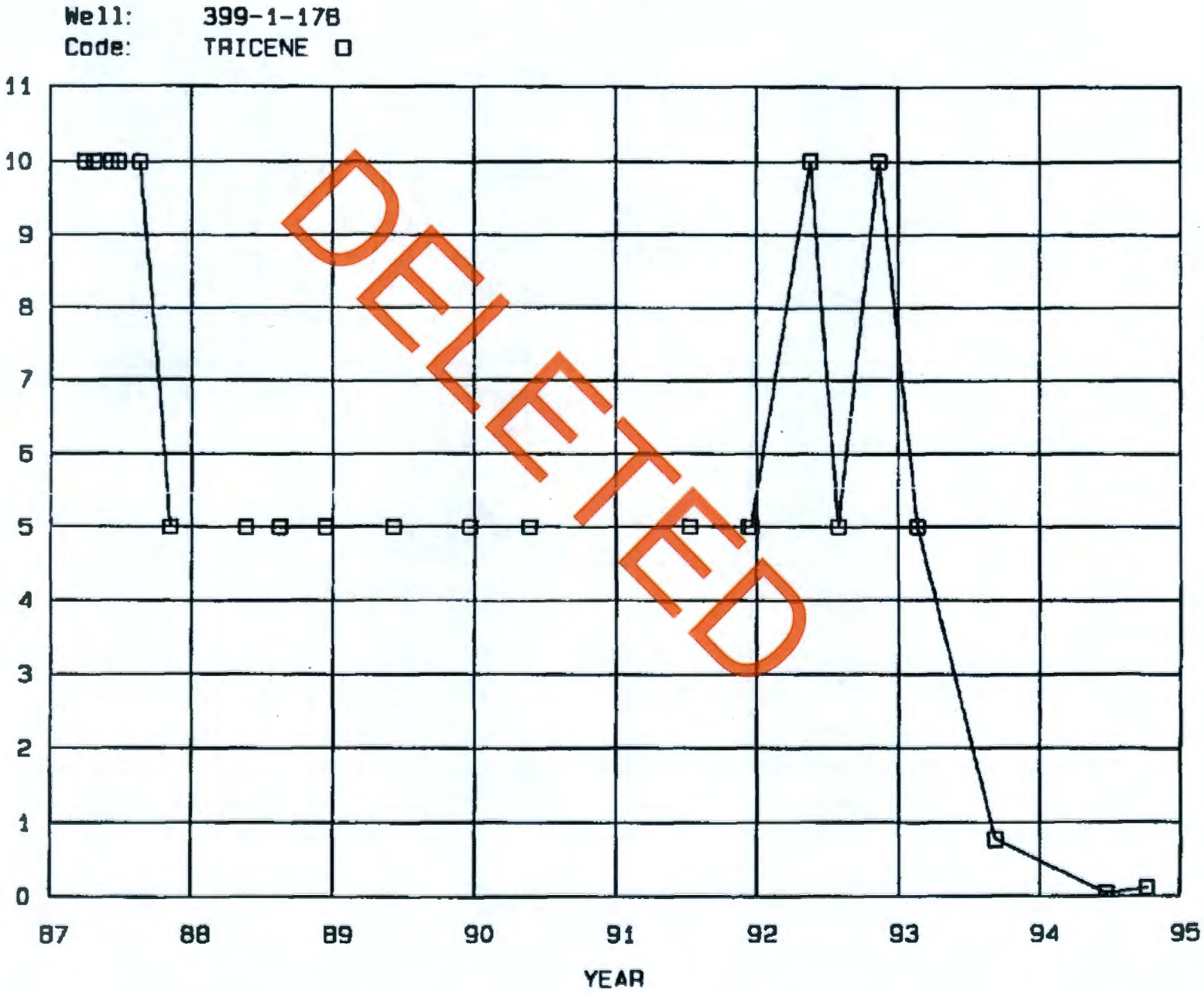



TCE (MCL 5 ppb) DCE (MCL 70 ppb)
Well: 399-2-2 399-2-2
Code: CIS12DE TRICENE
DELETED
MEASUREMENT (ppb)
0
1
2
3
4
5
6
7
8
9
10
11
12
88
89
90
91
92
93
94
95
YEAR

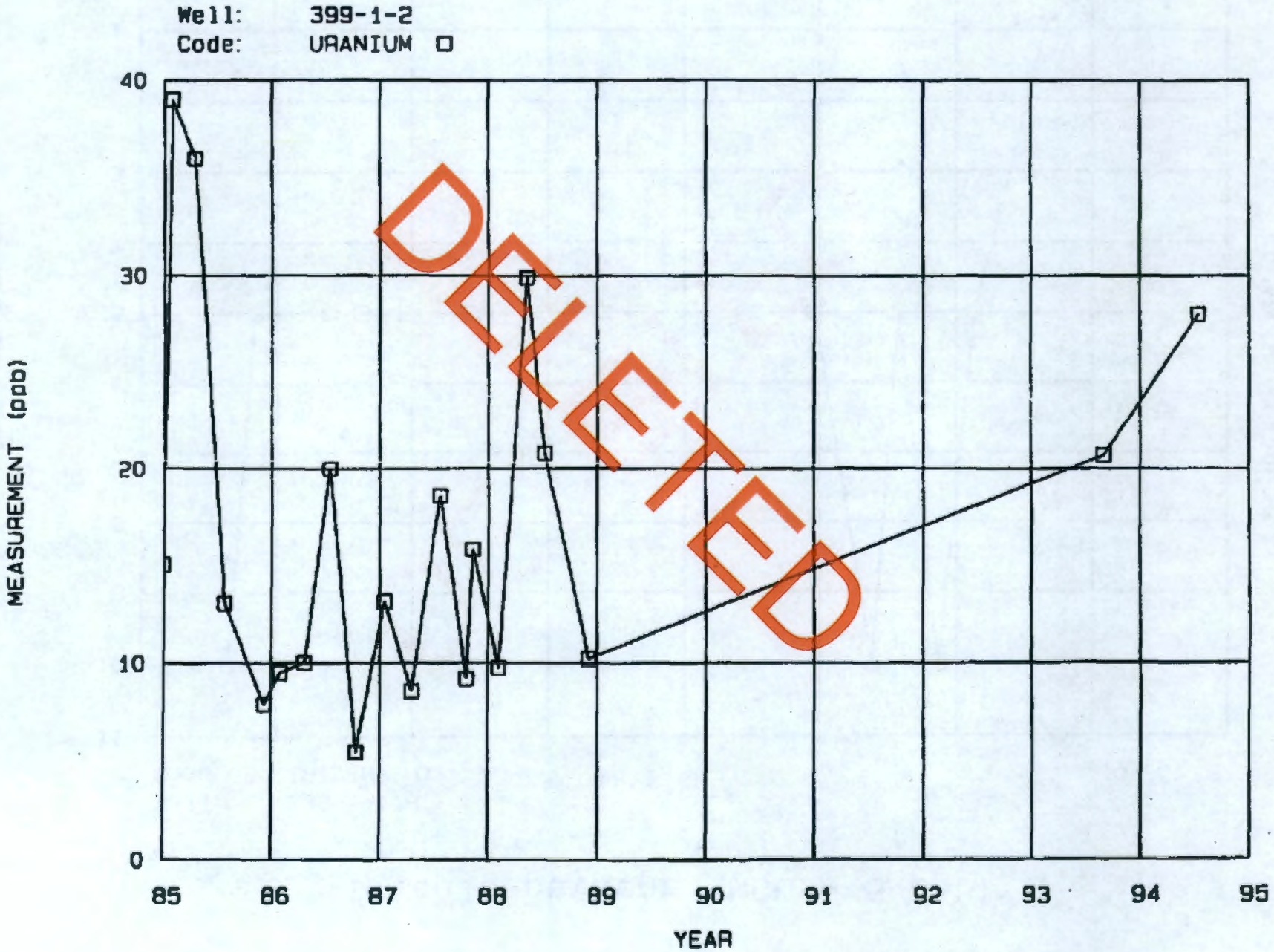
Trichloroethene MCL = 5 ppb



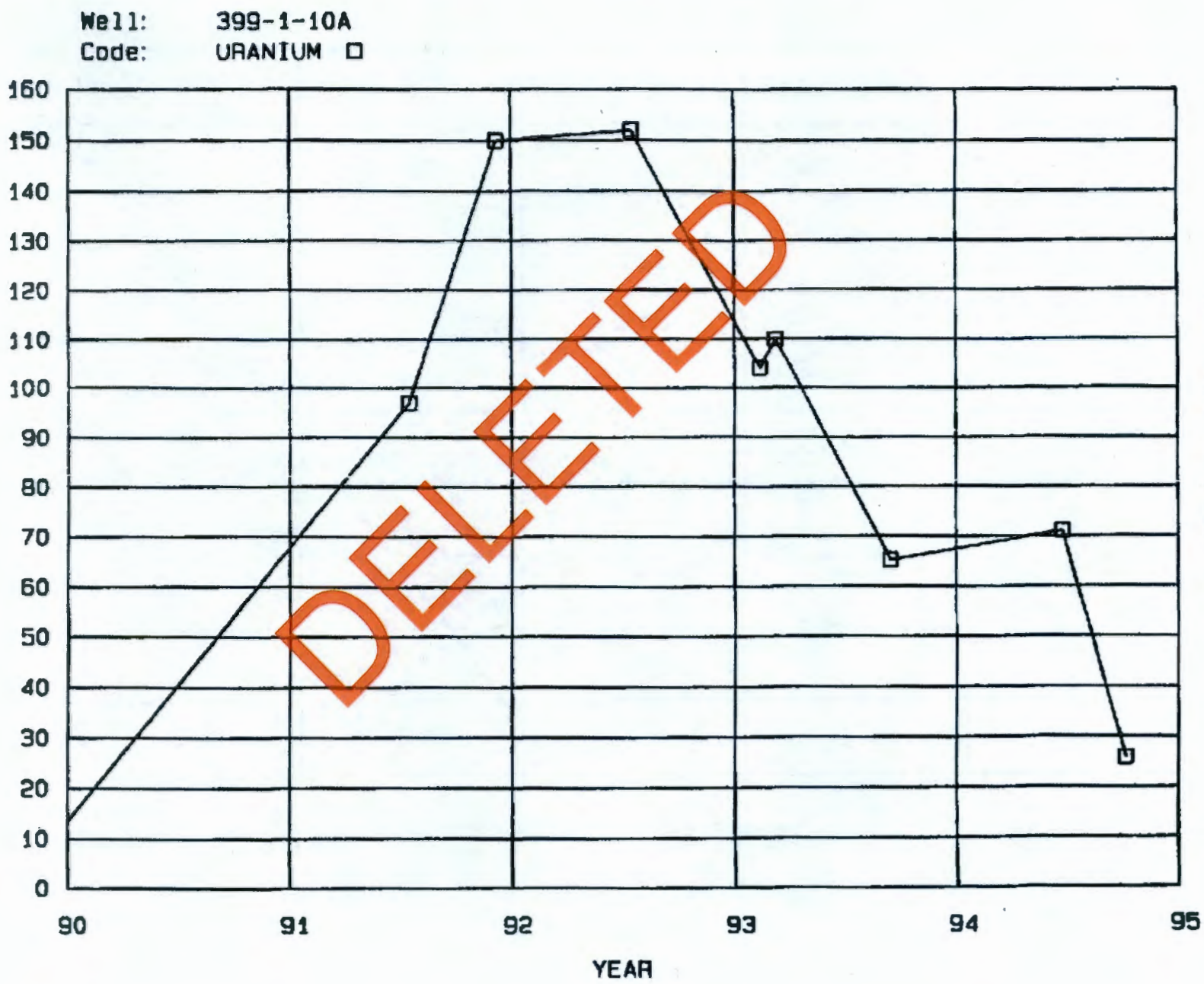
Trichloroethene (MCL = 5 ppb)

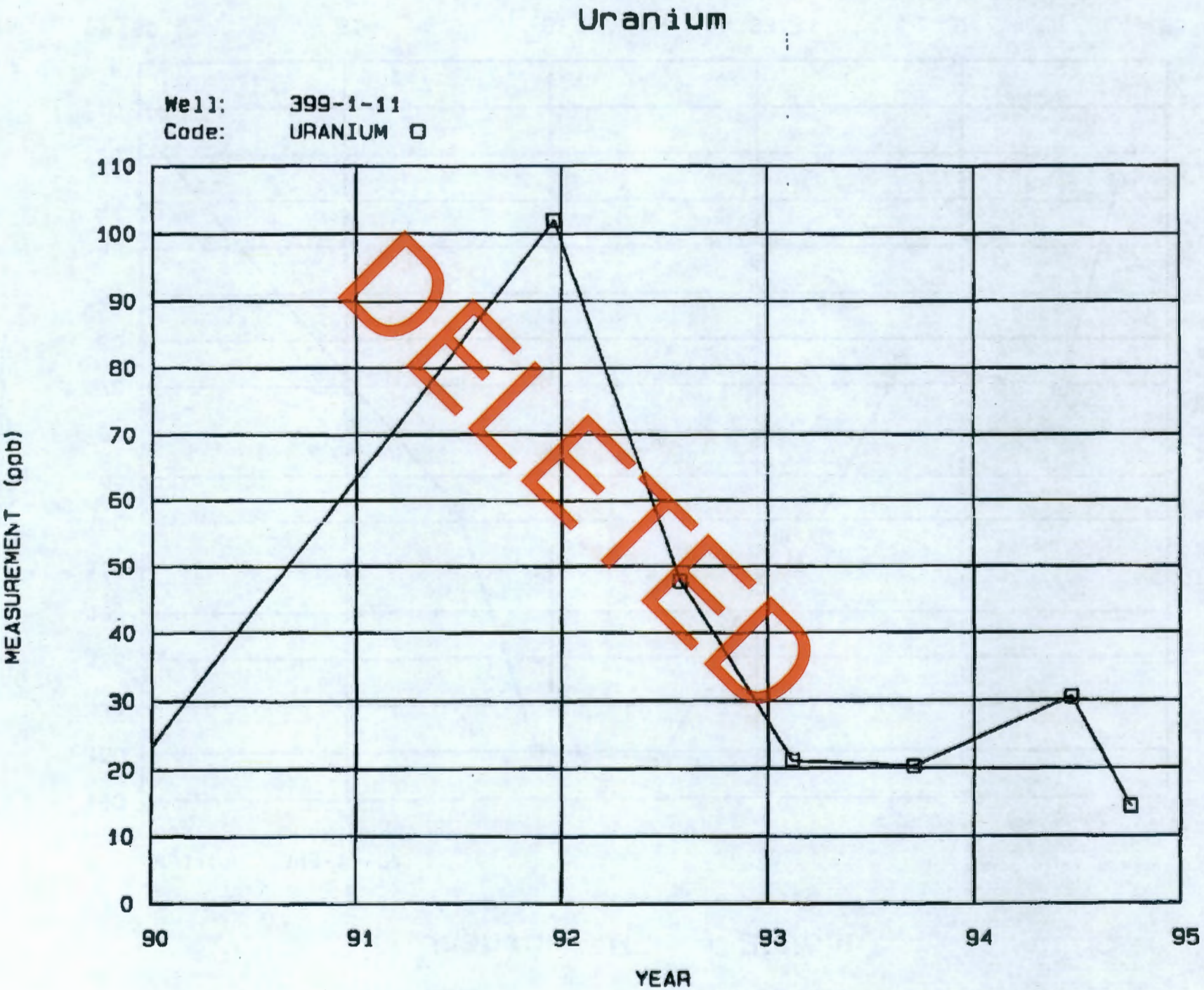


Uranium

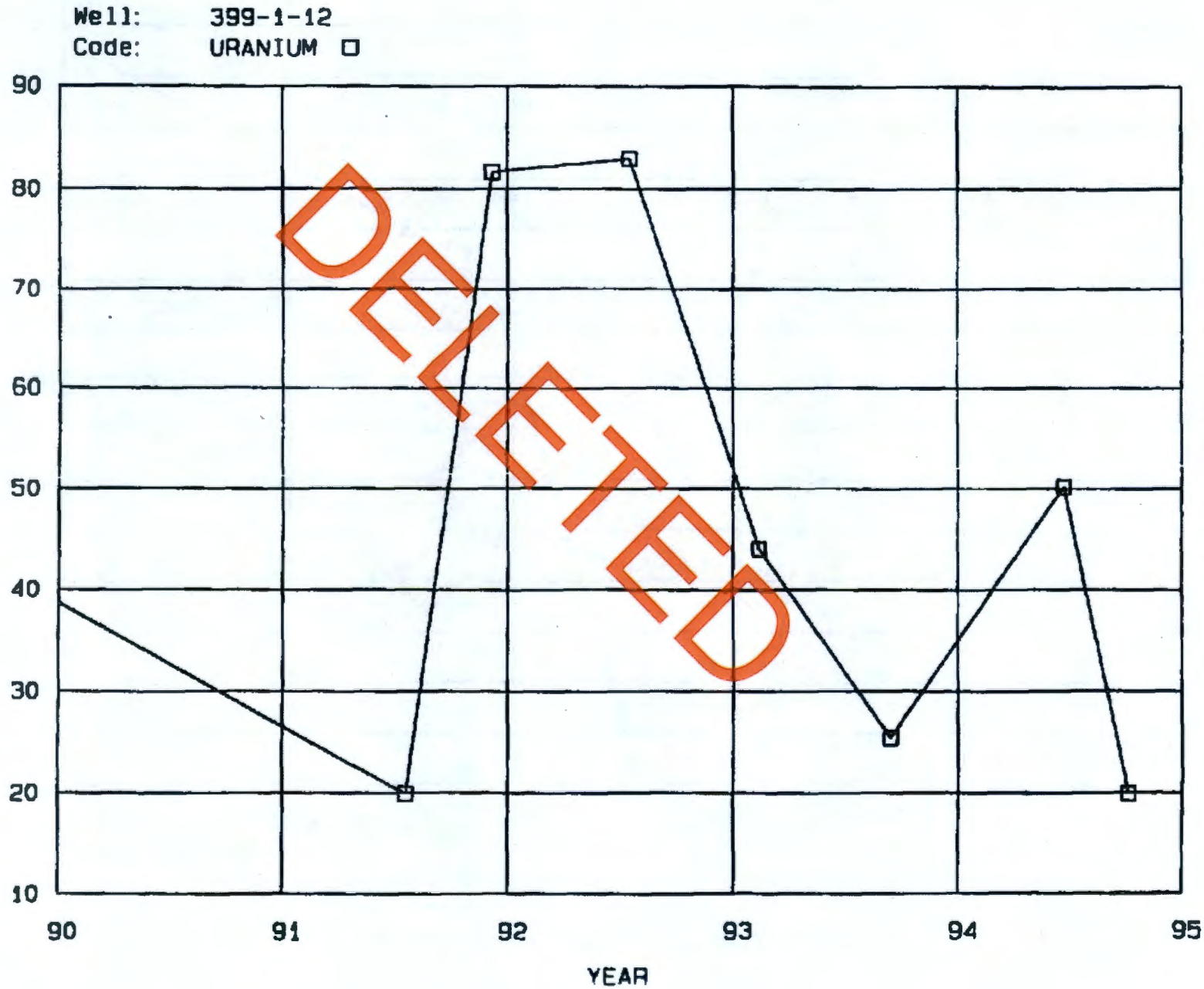

Well: 399-1-2
Code: URANIUM
DELETED
MEASUREMENT (ppb)
0
10
20
30
40
85
86
87
88
89
90
91
92
93
94
95
YEAR

Uranium MCL = 20 ppb

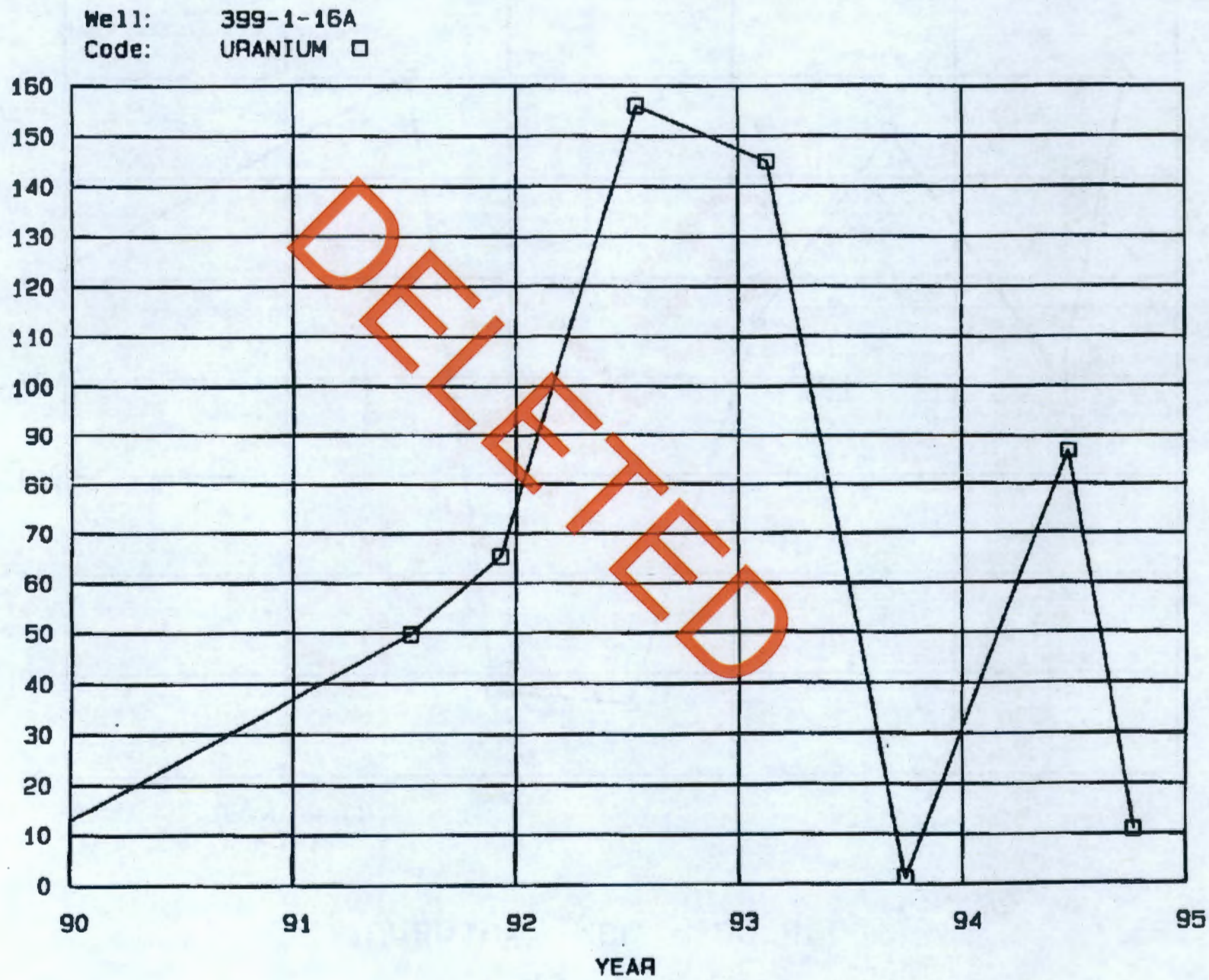



Uranium
Well: 399-1-11
Code: URANIUM
DELETED
MEASUREMENT (ppb)
110
100
90
80
70
60
50
40
30
20
10
0
90
91
92
93
94
95
YEAR

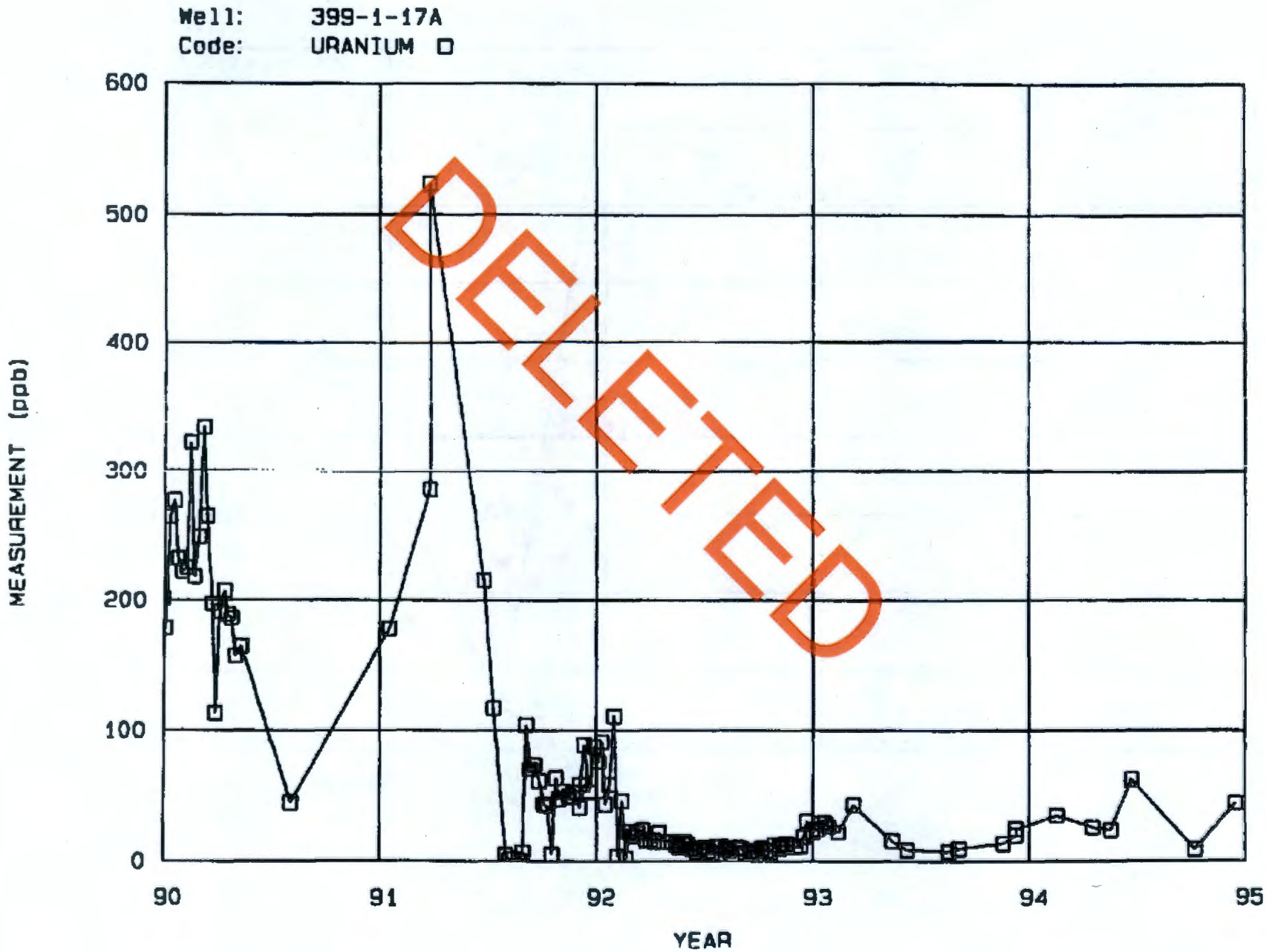
Uranium MCL = 20 ppb



Uranium MCL = 20 ppb



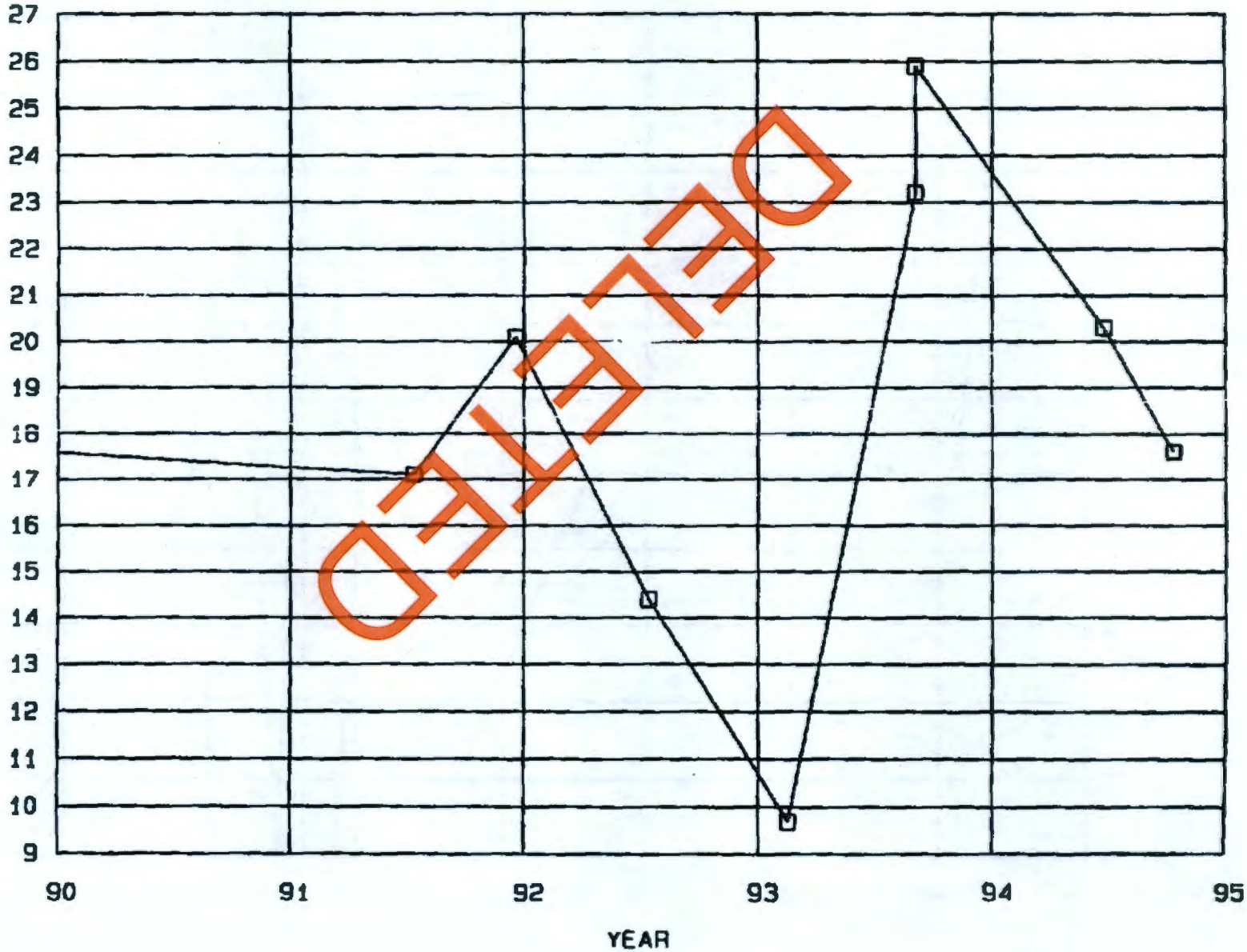
Uranium MCL = 20 ppb



Uranium MCL = 20 ppb

Uranium MCL = 20 ppb

Well: 399-3-10
Code: URANIUM



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Xylene (MCL = 10000 ppb)

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APPENDIX D

WELL CONSTRUCTION AND COMPLETION SUMMARIES

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WELL CONSTRUCTION AND COMPLETION SUMMARY

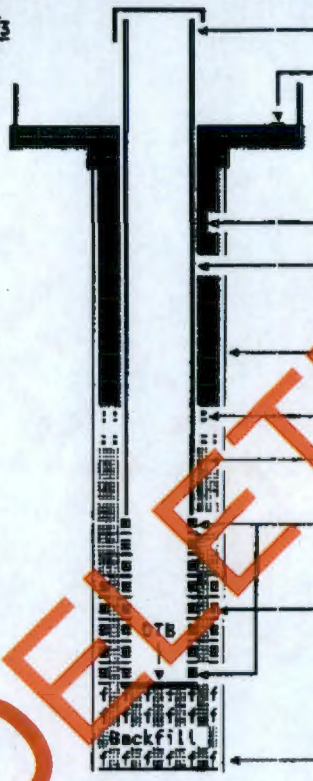
Drilling Method: Cable tool	Sample Method: Drive barrel
Drilling Fluid Used: 300 Area Water Supply	Additives Used: Not documented
Driller's Name: Cordon	WA State Lic Nr: 0079
Drilling Company: Associated Drillers	Company Location:
Date Started: 13Nov86	Date Complete: 22Nov86

WELL NUMBER: 399-1-10A	TEMPORARY WELL NO: S-3
Hanford Coordinates: N/S S 22,293	E/W E 14,413
State RN 57,083.8	RE 16,018.6
Coordinates: N Not documented	E Not doc
Start Card #: Not documented	T___ R___ S___
Elevation Ground surface: 371.94-ft Brass cap	

Depth to water: 29.0-ft Nov86
(Ground surface) 29.4-ft 17Dec93

GENERALIZED STRATIGRAPHY Log — Geologist's Log

0-10: Coarse to medium SAND
10-20: Sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, sandy PEBBLES



- Elevation of reference point: [373.65-ft] (top of casing)
- Height of reference point above ground surface [1.71-ft]
- Depth of surface seal [0-13.5-ft] Type of surface seal: Portland cement 4-ft x 4-ft x 6-in(nom) extending 3-ft into annulus.
- Bentonite crumbles to 13.5-ft
- 6-in ID stainless steel casing, +1.7-24.5-ft
- Hole diameter 0-45.0-ft, 11-in nominal
- Volclay bentonite pellets, 13.5-18.5-ft
- Silica sand pack, 18.5-39.5-ft, 8-12-mesh
- 6-in stainless steel screen 24.5-39.5-ft, #40-slot
- 10-in telescoping screen, 29.5-39.5-ft
- DTB=Depth to bottom, 39.1-ft, 12Feb92
- Borehole drilled depth: [45.0-ft]

DELETED

Drawing By: RKL/3-D1-10A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Raw water
Driller's Name: D Roesman
Drilling Company: Kaiser Engineers
Date Started: 06Sep91

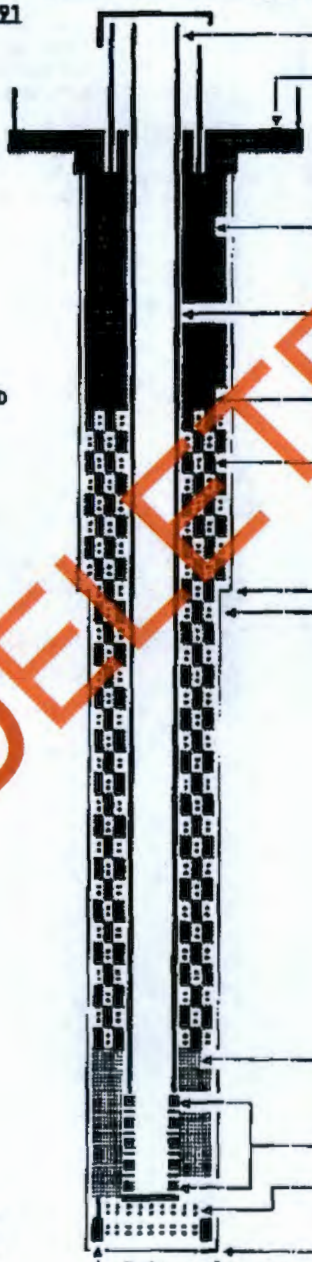
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 08Oct91

WELL NUMBER: 399-1-10B
TEMPORARY WELL NO: 1-10B
Hanford Coordinates: N/S Not documented E/W Not doc
State NAD83 RN 57,067.3 RE 16,033.3
Coordinates: N 116,729.06m E 594,351.09m
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 372.47-ft Brass cap

Depth to water: 37.7-ft 08Oct91 (Ground surface)

GENERALIZED Geologist's STRATIGRAPHY Log

0-8: SAND
8-10: Silty SAND
10-35: Gravelly silty SAND
35-39.4: Sandy GRAVEL
39.4-49.6: Gravelly SAND
49.6-54.7: Sandy GRAVEL
54.7-72: Gravelly SAND
72-73: SILT
73-79.8: Gravelly SAND
79.8-80.1: Gravelly SILT
80.1-98: Gravelly SAND
98-109.8: Slightly gravelly SAND
109.8-113: Gravelly SAND
113-119: SILT



Elevation of reference point: [375.58-ft] (top of inner casing)
Height of reference point above ground surface [3.11-ft]
Depth of surface seal [0-20.3-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad extends 2.5-ft into annulus
Portland cement grout to 20.3-ft
4-in ID T304 stainless steel casing, +3.5-104.5-ft
Bentonite crumbles, 20.3-28.2-ft
Bentonite slurry, 28.2-99.0-ft
Hole diameter, 0-53.0-ft, 10.95-in
53.0-119.0-ft, 8.8-in
Silica sand pack, 99.0-100.8-ft, 40-100-mesh
100.8-114.4-ft, 20-40-mesh
4-in T304 stainless steel screen, 104.5-114.5-ft, #10-slot
Bentonite hole plug, 115.3-119.0-ft
Borehole drilled depth: [119.0-ft]
8-in casing shoe cut off and left in hole, ~117.0-119.0-ft

Drawing By: RKL/3-01-10B.ASB
Date : 31Jan94
Reference : HANFORD WELLS WHC-SD-EN-TI-052

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WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Amos
Drilling Company: Associated Drillers
Date Started: 01Dec86

Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1224
Company Location:
Date Complete: 04Dec86

WELL NUMBER: 399-1-16A
TEMPORARY WELL NO: C-1A
Hanford Coordinates: N/S S 23,341 RN 56,035.6
E/W E 14,304 RE 15,910.1
State Coordinates: N Not documented E Not documented
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 380.21-ft Brass cap

Depth to water: 40.0-ft Dec86
(Ground surface) 38.1-ft 17Dec93

GENERALIZED STRATIGRAPHY Log — Geologist's

0-15: Silty, sandy GRAVEL
15-20: Clayey, sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, gravelly SAND
35-45: Silty SAND with CLAY and GRAVEL
45-TD: Silty, gravelly SAND

Elevation of reference point: [381.51-ft] (top of casing)
Height of reference point above ground surface [1.30-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad
Cement to 5.0-ft
6-in ID stainless steel casing, +1.3-32.5-ft
Bentonite crumbles, 5.0-21.0-ft
Hole diameter, 0-47.5-ft, 11-in nominal
Bentonite pellets, 21.0-24.8-ft
Silica sand pack, 24.8-47.5-ft, 10-20-mesh
6-in stainless steel screen, 32.5-47.5-ft, #20-slot
10-in telescoping screen, 37.5-47.5-ft, #40-slot
Borehole drilled depth: [47.5-ft]
DTB=Depth to bottom, 47.8-ft, 04Dec90

DELETED

Drawing By: RKL/3-01-16A.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon/Amos
Drilling Company: Associated Drillers
Date Started: 29Jan87

Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1517/1224
Company Location:
Date Complete: 10Feb87

WELL NUMBER: 399-1-16B
TEMPORARY WELL NO: C-1D
Hanford Coordinates: N/S S 23,350 E/W E 14,326
State RW 56,026.9 RE 15,931.6
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 380.03-ft Brass cap

Depth to water: 37.5-ft Feb87
(Ground surface) 37.8-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-10: Sandy GRAVEL
10-35: Silty, sandy GRAVEL
35-45: Gravelly, silty, clayey SAND
45-60: Silty, sandy GRAVEL
60-65: Clayey, silty, sandy GRAVEL
65-75: Silty, gravelly SAND
75-80: Silty, sandy GRAVEL
80-85: Clayey, sandy GRAVEL
85-90: Gravelly, silty, clayey SAND
90-95: Sandy GRAVEL
95-110: Silty, sandy GRAVEL
110-TD: Clayey, silty sandy GRAVEL

Elevation of reference point: [381.14-ft]
(top of casing)
Height of reference point above ground surface [1.11-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal:
4-ft x 4-ft surface pad
Cement to 5.0-ft
6-in ID stainless steel casing, +1.1-105.0-ft
Bentonite crumbles, 5.0-26.0-ft
Bentonite clay tablets, 26.0-99.7-ft
Hole diameter,
0-60.0-ft, 13-in nominal
60.0-118.0-ft, 11-in nominal
Silica sand pack, 99.7-118.0-ft, 8-12-mesh
6-in stainless steel screen, 105.0-115.0-ft, #20-slot
Borehole drilled depth: [118.0-ft]

DTB-Depth to bottom, 115.5-ft, 03Dec90

Drawing By: RKL/3-01-16B.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

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WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 08Nov86

Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 13Nov86

WELL NUMBER: 399-1-17A
TEMPORARY WELL NO: C-2A
Hanford Coordinates: N/S S 23,331 E/W E 13,630
State Coordinates: N RN 56,045.7 E RE 15,236.2
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.13-ft Brass cap

Depth to water: 32.3-ft Nov86
(Ground surface) 33.2-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-10: Sandy GRAVEL
10-25: Silty, sandy GRAVEL
25-35: Silty, gravelly SAND
35-40: Silty SAND

Elevation of reference point: [377.67-ft] (top of casing)
Height of reference point above ground surface [2.3-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal: 4-ft x 4-ft concrete pad.
Cement to 5.0-ft
6-in 10 stainless steel casing, 5.0-25.0-ft
Bentonite crumbles, 5.0-19.4-ft
Hole diameter, 0-41.0-ft, 11-in nominal
Volclay bentonite pellets, 19.4-21.6-ft
Silica sand pack, 21.6-41.0-ft
6-in stainless steel screen, 25.0-40.0-ft, #40-slot
Borehole drilled depth: [41.0-ft]
DTB=Depth to bottom, 41.5-ft, 03Dec90

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Drawing By: RKL/3-01-17A.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 01Dec86

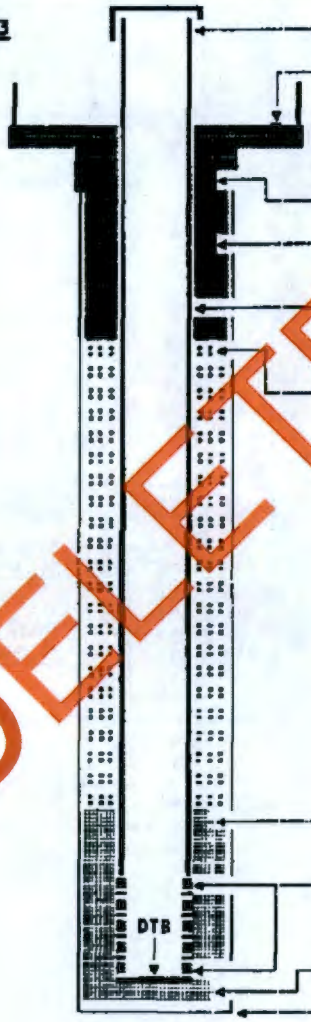
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1517
Drilling Company Location:
Date Complete: 19Dec86

WELL NUMBER: 399-1-17B
TEMPORARY WELL NO: C-2B
Hanford Coordinates: N/S S 23,317 E/W E 13,604
State RN 56,059.5 RE 15,210.3
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.48-ft Brass cap

Depth to water: 32.9-ft Dec86
(Ground surface) 33.3-ft 17Dec93

GENERALIZED Geologist's STRATIGRAPHY Log

0-5: Silty SAND
5-15: Silty, sandy PEBBLES
15-25: Sandy PEBBLES
25-30: Gravelly SAND
30-35: Sandy GRAVEL
35-40: Sandy PEBBLES
40-55: Sandy GRAVEL
55-70: Silty, sandy GRAVEL
70-85: Sandy GRAVEL
85-90: Silty, sandy GRAVEL
90-95: Sandy GRAVEL
95-105: Silty, sandy GRAVEL
105-110: Silty, gravelly SAND
110-115: Sandy, gravelly CLAY



Elevation of reference point: [377.87-ft]
(top of casing)
Height of reference point above [2.39-ft]
ground surface
Depth of surface seal [0-4.0-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 4.0-ft
Bentonite crumbles,
4.0-[illegible].0-ft
6-in ID stainless steel casing,
±2.4-100.0 ft
Volclay tablets,
[illegible]-95.0-ft
Silica sand pack,
95.0-113.5-ft, 8-12-mesh
6-in stainless steel screen, [100.0-ft]
100-110-ft, #40-slot
Fill,
113.5-115.0-ft
Borehole drilled depth: [115.0-ft]

DTB=Depth to bottom,
110.2-ft, 03Dec90

DELETED

Drawing By: RKL/3-01-17B.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 06Nov86
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 12Nov86

WELL NUMBER: 399-1-18A
TEMPORARY WELL NO: C-3A
Hanford Coordinates: N/S N 20,407 E/W E 12,877
State RN 58,970.1 RE 14,483.3
Coordinates: N 384,928 E 2,308,254
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 387.77-ft Brass cap

Depth to water: 47.0-ft Nov86
(Ground surface) 44.9-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-5: No record
5-15: Silty SAND
15-35: Gravelly SAND
35-45: Silty, gravelly SAND
45-60: Gravelly SAND with trace of SILT
60-TD: Sandy GRAVEL with trace of SILT and CLAY

Elevation of reference point: [390.83-ft] (top of casing)
Height of reference point above ground surface [3.06-ft]
Depth of surface seal [0-5.5-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad
Cement to 5.5-ft
Bentonite crumbles, 5.5-31.8-ft
6-in ID stainless steel casing, +3.1-39.0-ft
Hole diameter, 0-63.0-ft, 11-in nominal
Volclay bentonite pellets, 31.8-34.0-ft
Silica sand pack, 34.0-54.0-ft, 8-12-mesh
6-in stainless steel screen, 39.0-54.0-ft, #40-slot
10-in telescoping screen, 39.0-54.0-ft
Gravel pack to 54.4-ft
Fill, 54.4-63.0-ft
Borehole drilled depth: [63.0-ft]
DTB=Depth to bottom, 53.8-ft, 06Nov90

DELETED

Drawing By: RKL/3-01-18A.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 399-1-188
Drilling Fluid Used: 300 Area Water Supply	Additives Used: Not documented	TEMPORARY WELL NO: C-38
Driller's Name: Cordon	WA State Lic Nr: 0079	Hanford Coordinates: N/S S 20,420 E/W E 12,865
Drilling Company: Associated Drillers	Company Location:	State RN 58,956.5 RE 14,470.8
Date Started: 13Nov86	Date Complete: 20Jan87	Coordinates: N Not documented E Not doc
		Start Card #: Not documented T___ R___ S___
		Elevation Ground surface: 387.24-ft Brass cap

Depth to water: 42.5-ft Jan87
(Ground surface) 44.0-ft 17Dec93

GENERALIZED STRATIGRAPHY Log — Geologist's

0-5: Not documented
5-11: SAND
11-15: SAND and GRAVEL
15-25: Sandy GRAVEL
25-30: Silty, sandy GRAVEL
30-40: Sandy GRAVEL with trace of SILT
40-50: Silty, sandy GRAVEL
50-55: Pebbly SAND
55-60: Sandy, silty GRAVEL
60-65: Pebbly SAND
65-85: Silty, sandy GRAVEL
85-90: Sandy SILT
90-95: Silty, sandy GRAVEL
95-115: Sandy, silty GRAVEL
115-120: Silty, sandy GRAVEL
120-125: Sandy, clayey GRAVEL
125 : Sandy, gravelly CLAY

Elevation of reference point: [389.94 ft] (top of casing)
Height of reference point above ground surface [2.70-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad
Cement to 5.0-ft
Bentonite crumbles, 5.0-34.0-ft
6-in ID stainless steel casing, +2.7-108.5-ft
Hole diameter, 0-125.0-ft, 11-in nominal
Volclay grout, 34.0-105.0-ft
Silica sand pack, 105.0-118.0-ft, 8-12-mesh
6-in stainless steel screen, 108.5-118.5-ft, #40-slot
Fill, 118.0-125.0-ft
Borehole drilled depth: [125.0-ft]

Drawing By: RKL/3-01-188.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

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DOE/RL-2015-29
Revision 0

Final Status Groundwater Monitoring Plan for the 300 Area Process Trenches

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2015-29
Revision 0

Final Status Groundwater Monitoring Plan for the 300 Area Process Trenches

Date Published
November 2016

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APPROVED
By Julia Raymer at 2:18 pm, Nov 02, 2016

Release Approval Date

Approved for Public Release;
Further Dissemination Unlimited

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Executive Summary

This document presents a revision to the 1995 (1996 revised) 300 Area Process Trenches groundwater monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A).[1,2] This revised monitoring plan is based on the requirements for final status facilities, as identified in the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*[3] (hereafter referred to as the Hanford Facility RCRA Permit), Part II, Condition II.F, which specifies that final status groundwater monitoring programs are subject to the requirements in WAC 173-303-645.[4] Due to the age of the plan, the U.S. Department of Energy (DOE), Richland Operations Office is revising this groundwater monitoring plan to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the post-closure unit group (changes in the constituents to be monitored, sampling frequency, concentration limits, statistical evaluation, and clarification of compliance period). This document will supersede the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) upon modification of the Hanford Facility RCRA Permit. This corrective action groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at the 300 Area Process Trenches.

The 300 Area Process Trenches are a final status, post-closure unit group (Post Closure Unit Group 1), located in the 300-FF-1 Source Operable Unit (OU), that are undergoing corrective action groundwater monitoring. The 300 Area Process Trenches are located in the northern section of the 300 Area Industrial Complex approximately 300 m (980 ft) west of the Columbia River. The facility consisted of two 460 m (1,500 ft) long trenches

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[1] WHC-SD-EN-AP-185, 1995, *Groundwater Monitoring Plan for the 300 Area Process Trenches*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/vewDoc?accession=D196020117.

[2] WHC-SD-EN-AP-185, 1996, *Groundwater Monitoring Plan for the 300 Area Process Trenches*, Rev. 0A, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196135178.

[3] WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste,* Revision 8c, as amended, Washington State Department of Ecology, Richland, Washington. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/.

[4] WAC 173-303-645, "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

used for effluent discharge from the 300 Area process sewer system. The site was closed under a modified closure; that is, the site was remediated and the soil column was clean closed in 1998 with post-closure requirements for groundwater monitoring (Ecology, 1998).[5]

The 300 Area Process Trenches received wastewater contaminated with dangerous waste or dangerous waste constituents. Per the Hanford Facility RCRA Permit, a final status groundwater compliance monitoring program in accordance with WAC 173-303-645 was implemented in 1995 (WCH-SD-EN-AP-185, Rev. 0). The constituents identified for monitoring in the plan were *cis*-1,2-dichloroethene (*cis*-1,2-DCE), trichloroethene (TCE), and uranium. Gross alpha, gross beta, iron, manganese, and field parameters (pH, conductivity, turbidity, and temperature) were also monitored.

The first samples collected under the compliance monitoring plan exceeded concentration limits for *cis*-1,2-DCE, TCE, and uranium. As a result, corrective action was required. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[6] (CERCLA) action for the 300-FF-5 OU (institutional controls [ICs] and groundwater monitoring) was implemented in EPA/ROD/R10-96/143.[7] Corrective action for the 300 Area Process Trenches was deferred to the CERCLA program for the 300-FF-5 Groundwater OU.

The constituents for monitoring were revised in 1996 (WCH-SD-EN-AP-185, Rev. 0A) and included *cis*-1,2-DCE, TCE, and uranium as constituents of concern, with iron and manganese included for a follow-up geochemical evaluation. Additionally, thallium, polychlorinated biphenyls (PCBs), chrysene, and benzo(a)pyrene were monitored for two years. Field parameters (pH, conductivity, turbidity, and temperature) were also included. Although written as a compliance monitoring plan, WHC-SD-EN-AP-185

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[5] Ecology, 1998, "Acceptance of Certification of the 300 Area Process Trenches Clean Closure of the Soil Column and Ground Water Corrective Action Requirements" (letter to J.E. Rasmussen, U.S. Department of Energy, from T.A. Wooley, Nuclear Waste Program), Washington State Department of Ecology, Kennewick, Washington, August 10. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D198148423.

[6] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

[7] EPA/ROD/R10-96/143, 1996, *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=1000544M.TXT

(Rev. 0 and Rev. 0A) was accepted as the corrective action monitoring plan for the 300 Area Process Trenches by the Washington State Department of Ecology in 1998.

The U.S. Environmental Protection Agency (EPA) and DOE issued the 300 Area Record of Decision [ROD]/ROD Amendment[8] in 2013. Groundwater contaminants of concern identified for remedial action in the 300 Area Industrial Complex include uranium, *cis*-1,2-DCE, and TCE, which are the 300 Area Process Trenches constituents of concern that were identified in the previous corrective action monitoring plan. The soil and groundwater remedies affecting the 300 Area Process Trenches area include enhanced attenuation of uranium; groundwater monitoring of uranium; monitored natural attenuation of *cis*-1,2-DCE and TCE; and ICs.

This revised groundwater monitoring plan updates the dangerous waste constituents for corrective action monitoring and removes constituents that no longer require monitoring. The dangerous waste constituents identified for monitoring at the 300 Area Process Trenches are *cis*-1,2-DCE and TCE. Other constituents identified for monitoring in the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) are not included in this revision. Monitoring of uranium is conducted under the CERCLA remedial action and is not included in this monitoring plan. PCBs, benzo(a)pyrene, and chrysene were not detected the 300 Area Process Trenches groundwater monitoring network during the required two years of monitoring and therefore do not require further monitoring. Thallium was detected during the required two years of monitoring but was determined to be naturally occurring.[9] A geochemical evaluation of elevated iron and manganese concentrations at the bottom of the unconfined aquifer determined that these concentration levels are attributable to naturally occurring reducing conditions.[10]

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[8] EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*, U.S. Environmental Protection Agency and U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087180.

[9] DOE/RL-2010-99, 2013, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Rev. 0, Sections 4.4.2.3 and 4.4.4.1, and Table 4-24, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088359.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088307.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088306.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088305.

[10] ECF-300FF5-14-0044, 2014, *300 Area Process Trenches Geochemical Evaluation of Elevated Dissolved Iron and Manganese Concentrations in the Lower Unconfined Aquifer*, Rev. 0, Sections 4.4.2.3 and 4.4.4.1, and Table 4-24, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082020H.

This revised groundwater monitoring plan presents a corrective action monitoring plan for the uppermost aquifer beneath the 300 Area Process Trenches. This plan addresses the following:

- Number, locations, and depths of wells in the 300 Area Process Trenches groundwater monitoring network
- Sampling and analytical methods of dangerous waste required under corrective action monitoring
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at the 300 Area Process Trenches

This revised plan uses the existing groundwater monitoring well network as identified in the previous groundwater monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) with the downgradient wells representing the point of compliance. The concentration limits for *cis*-1,2-DCE and TCE are revised in this plan to 16 µg/L and 4 µg/L, respectively, which are the cleanup levels in the 300 Area ROD/ROD Amendment. The concentration limits are based on WAC 173-340-720(4)[11] cleanup levels. Groundwater flow direction determinations indicate that the groundwater flow direction beneath the 300 Area Process Trenches is east or southeast during low river stage and south or southwest during high river stage. Groundwater in the 300 Area Process Trenches monitoring wells will be sampled and analyzed semiannually for *cis*-1,2-DCE and TCE. Field parameters (pH, specific conductance, temperature, and turbidity) will also be collected. Water level measurements will be taken each time a sample is collected to satisfy the requirements of WAC 173-303-645(8)(f).

[11] WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720.

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Terms

AEA	*Atomic Energy Act of 1954*
amsl	above mean sea level
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cis-1,2-DCE	*cis*-1,2-dichloroethene
COC	contaminant of concern
CSM	conceptual site model
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
FWS	Field Work Supervisor
HSU	hydrostratigraphic unit
IC	institutional control
MNA	monitored natural attenuation
NAD83	*North American Datum of 1983*
NAVD88	*North American Vertical Datum of 1988*
OU	operable unit
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
TCE	trichloroethene

Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TSD	treatment, storage, and disposal
UCL	upper confidence limit
VOC	volatile organic compound
WAC	*Washington Administrative Code*

1 Introduction

This document presents the revised groundwater monitoring plan for the 300 Area Process Trenches and supersedes the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A, *Groundwater Monitoring Plan for the 300 Area Process Trenches)*. The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the post-closure unit group (changes in the constituents to be monitored, sampling frequency, concentration limits, statistical evaluation, and clarification of compliance period). The 300 Area Process Trenches are a post-closure unit group in Part VI, Unit 1, of the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereafter referred to as the Hanford Facility RCRA Permit). Soil remediation of the trenches was completed in 1998, and the unit was closed in 1998 under modified closure conditions in the Hanford Facility RCRA Permit with requirements for continued groundwater monitoring in post-closure care (Ecology, 1998, "Acceptance of Certification of the 300 Area Process Trenches Clean Closure of the Soil Column and Ground Water Corrective Action Requirements"). The Hanford Facility RCRA Permit, Part II, Condition II.F, specifies that final status groundwater monitoring program requirements will comply with WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." Groundwater is monitored in accordance with WAC 173-303-645 and Part VI, Unit 1, of the Hanford Facility RCRA Permit. For regulatory purposes, the boundary of the 300 Area Process Trenches unit group is identified on the current Hanford Facility RCRA Permit Part A Form.

The 300 Area Process Trenches (waste site 316-5) are located within the 300 Area Industrial Complex in the 300-FF-1 Operable Unit (OU) (Figure 1-1). The 300 Area Process Trenches comprised two, unlined 460 m (1,500 ft) long trenches that were excavated 3.7 m (12 ft) below ground surface. The trenches were one of the primary disposal facilities for 300 Area liquid process waste. Operating records indicate that the 300 Area Process Trenches began receiving wastewater from the 300 Area process sewer in 1975. An expedited response action (ERA) was performed in 1991 to relocate contaminated sediments to the north portions of the trenches (DOE/RL-91-11, *Expedited Response Action Proposal for the 316-5 Process Trenches*). Discharges to the 300 Area Process Trenches ceased in 1994, and remediation of the site was performed in 1997 and 1998.

RCRA compliance groundwater monitoring was initiated at the 300 Area Process Trenches in 1985 (as described in PNL-6671, *Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches*) based on the groundwater monitoring requirements for interim status facilities. In 1994, the Washington State Department of Ecology (Ecology) issued the Hanford Facility RCRA Permit for the Hanford Site, which included the Part II, Condition II.F requirement that final status treatment, storage, and disposal (TSD) units comply with WAC 173-303-645. As a final status compliance monitoring plan under WAC 173-303-645, WHC-SD-EN-AP-185 (Rev. 0) was incorporated into the Hanford Facility RCRA Permit and initiated in 1996.

Results for the initial compliance monitoring samples collected in late 1996 and early 1997 (Furman, 1997, "Exceedance of Concentration Limits in Groundwater at the 316-5 Process Trenches") showed exceedances of the concentration limits established per WAC 173-303-645(5) for *cis*-1,2-dichloroethene (*cis*-1,2-DCE), trichloroethene (TCE), and uranium. Based on the concentration limit exceedances, the regulations in WAC 173-303-645(11), "Corrective Action Program," require implementation of a corrective action program to reduce contaminant concentrations in groundwater.

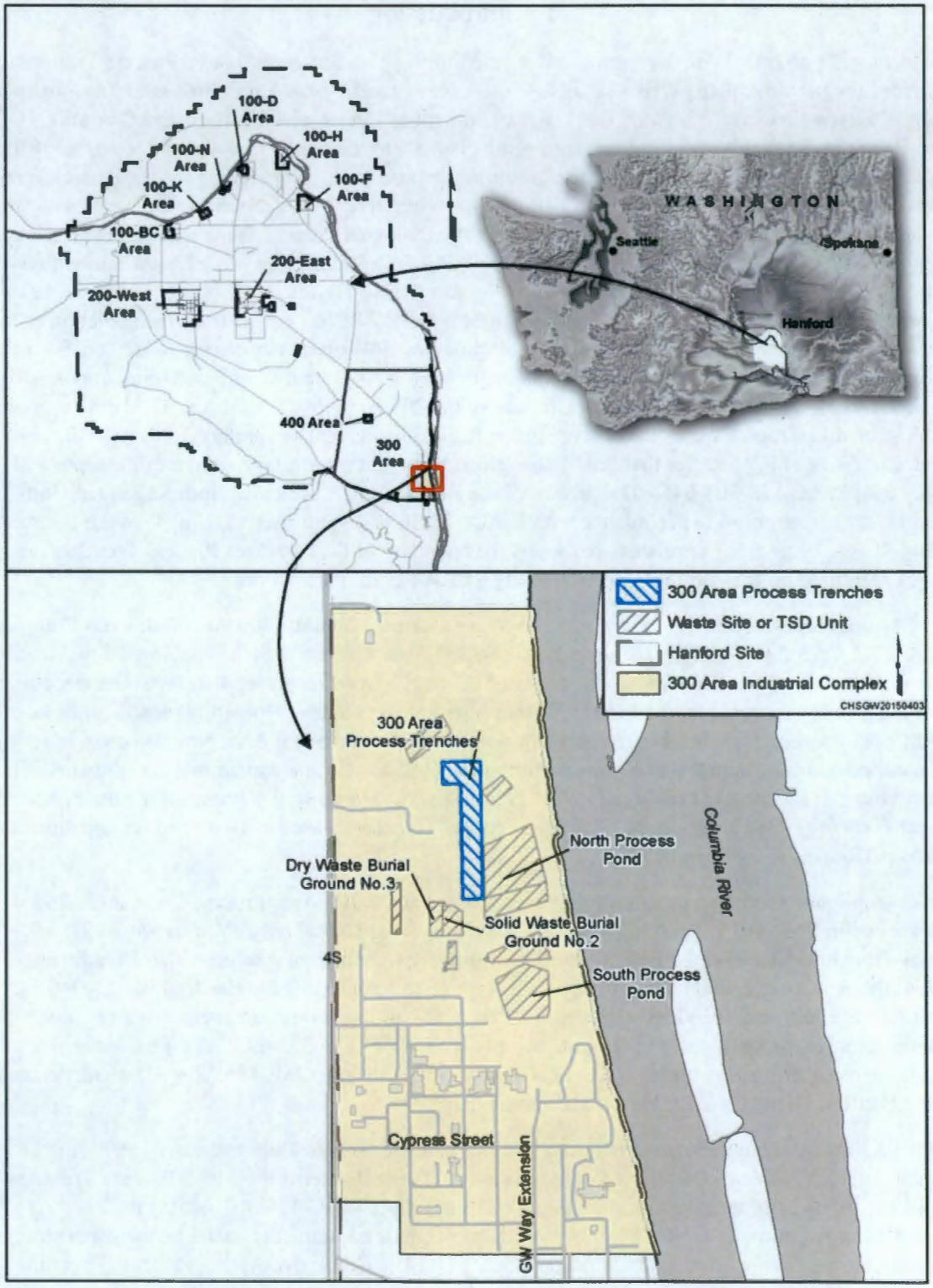


Figure 1-1. Location Map for the 300 Area Process Trenches

The monitoring plan (WHC-SD-EN-AP-185, Rev. 0, Chapter 6), which was incorporated into Chapter VI, Unit 1 of the Hanford Facility RCRA Permit, deferred further groundwater corrective action to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) action for the 300-FF-1 Source and 300-FF-5 Groundwater OUs. The 300-FF-5 OU alternative selected in EPA/ROD/R10-96/143, *Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington*, was groundwater monitoring and institutional controls (ICs) (groundwater use restrictions). This alternative required continued monitoring of contaminant trends under the corrective action plan and constituted the corrective action measures under WAC 173-303-645(11).

The monitoring plan (WHC-SD-EN-AP-185, Rev. 0) was revised in 1996 (Rev. 0A) to specify constituents for sampling but remained a compliance monitoring plan. Remediation of the 300 Area Process Trenches was conducted in 1997 and 1998 under an integrated CERCLA/RCRA process described in DOE/RL-93-73, *300 Area Process Trenches Modified Closure/Postclosure Plan*. While the soil portion of the 300 Area Process Trenches met clean closure performance standards under WAC 173-303-610, "Closure and Post-Closure," post-closure groundwater monitoring requirements under the Hanford Facility RCRA Permit and the 300-FF-5 OU record of decision (ROD) (EPA/ROD/R10-96/143) remained (Ecology, 1998). Remediation of the 300 Area Process Trenches under CERCLA (waste site 316-5) was completed and the site was reclassified to "closed out" in 1998. The existing groundwater compliance monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) was accepted without modification by Ecology in 1998 as the corrective action monitoring plan and was incorporated into DOE/RL-98-31, *300 Area Process Trenches Postclosure Plan*. WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) has remained the controlling document for the 300 Area Process Trenches groundwater monitoring.

The 300 Area ROD/ROD Amendment (EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1* [hereafter referred to as the 300 Area ROD/ROD Amendment]) was issued in 2013. The remedies affecting the 300 Area Process Trenches area include enhanced attenuation of uranium for soil and monitored natural attenuation (MNA), groundwater monitoring, and ICs for groundwater. The 300 Area ROD/ROD Amendment identifies groundwater contaminants of concern (COCs) in the 300 Area Industrial Complex. These include the constituents of concern identified in WHC-SD-EN-AP-185 (Rev. 0A): uranium and the dangerous waste constituents *cis*-1,2-DCE and TCE.

Remedies required under the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) include MNA for *cis*-1,2-DCE and TCE in the 300 Area Industrial Complex. A portion of the 300 Area Process Trenches is within the area identified for enhanced attenuation of uranium. Uranium in groundwater will be monitored until the cleanup level is achieved. ICs restricting groundwater access and use will be implemented until groundwater cleanup levels are achieved.

Cleanup levels for *cis*-1,2-DCE and TCE are identified in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013). Within the 300 Area Process Trenches monitoring network wells, TCE last exceeded the cleanup level of 4 µg/L established in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) in 1999. A 2015 CERCLA evaluation of TCE in 300 Area groundwater wells found that only one well (which does not monitor the 300 Area Process Trenches) had not attained the established cleanup level for TCE. Based on these results, monitoring for TCE under the CERCLA remedial action is not performed at any wells monitoring the 300 Area Process Trenches under DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, which was approved by the U.S. Environmental Protection Agency (EPA) in September 2015.

The purpose of this groundwater monitoring plan is to present an updated groundwater monitoring program for dangerous wastes from the 300 Area Process Trenches. This plan is intended specifically to satisfy monitoring requirements for a final status unit undergoing corrective action, as prescribed in Part VI of the Hanford Facility RCRA Permit and required by WAC 173-303-645(11). This monitoring plan is the principal controlling document for conducting groundwater monitoring at the 300 Area Process Trenches and is used to modify the permit. Once the permit is modified, this document will supersede WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A).

This revised plan monitors *cis*-1,2-DCE, TCE, and field parameters (pH, specific conductance, temperature, and turbidity). Monitoring of uranium is conducted under the CERCLA remedial action and is not included for monitoring in this plan. Polychlorinated biphenyls (PCBs), benzo(a)pyrene, and chrysene were not detected in the 300 Area Process Trenches groundwater monitoring network during the required two years of monitoring and do not require further monitoring. Thallium was detected during the required two years of monitoring and was determined to be naturally occurring based on evaluation in DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* and does not require further monitoring. A geochemical evaluation of elevated iron and manganese concentrations in the deep unconfined aquifer was performed in 2014 and found that the elevated concentrations are attributed to naturally occurring reducing conditions (ECF-300FF5-14-0044, *300 Area Process Trenches Geochemical Evaluation of Elevated Dissolved Iron and Manganese Concentrations in the Lower Unconfined Aquifer*, Section 8) and does not require further monitoring. The corrective action monitoring program detailed in this plan requires semiannual sampling and analysis of *cis*-1,2-DCE, TCE, and field parameters at two upgradient and six downgradient wells. Water level measurements are required each time a sample is collected to satisfy WAC 173-303-645(8)(f).

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the unit and incorporates knowledge regarding contamination originating from the 300 Area Process Trenches and includes the following chapters and appendices:

- Chapter 2 summarizes background information and references other documents that contain more detailed or additional information. It also describes the 300 Area Process Trenches and the regulatory basis, the types of waste present, and the pertinent geology and hydrogeology beneath the 300 Area Process Trenches; and it presents a brief history of groundwater monitoring. This information is summarized as the CSM to aid in development of the groundwater monitoring program.
- Chapter 3 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols.
- Chapter 4 describes data evaluation and reporting.
- Chapter 5 contains the references cited in this plan.
- Appendix A provides the quality assurance project plan (QAPjP).
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring network.
- Appendix D presents monitoring data of the dangerous wastes (*cis*-1,2-DCE and TCE) that have been collected from the network wells during corrective action monitoring.

2 Background

This chapter describes the 300 Area Process Trenches and their operating history, regulatory basis, wastes and waste characteristics associated with the 300 Area Process Trenches, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for the 300 Area Process Trenches.

The information contained in this chapter was obtained from several sources, including previous groundwater monitoring plans listed in Section 2.5 and the following documents:

- DOE/RL-91-11, *Expedited Response Action Proposal for the 316-5 Process Trenches*
- DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches*
- DOE/RL-98-31, *300 Area Process Trenches Postclosure Plan*
- DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*
- PNL-6716, *Interim Characterization Report for the 300 Area Process Trenches*
- PNNL-13645, *300 Area Process Trenches Groundwater Monitoring Plan*
- PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*

2.1 Facility Description and Operational History

The 300 Area Process Trenches are located in the northern portion of the 300 Area Industrial Complex about 300 m (985 ft) west of the Columbia River (Figure 2-1). The site began operating March 16, 1975, and was the main facility for disposal of most liquid process waste generated in the 300 Area from 1975 until the trenches were removed from service in December 1994. The liquid waste discharged to the 300 Area Process Trenches came only from the 300 Area process sewer and consisted mostly of wastewater with relatively low concentrations of chemical contaminants. More concentrated waste was generally not discharged to the process sewer and trenches. The discharge rate varied over the years, but it reached a maximum average of about 8,641 L/min (2,283 gallons per minute [gpm]) during 1979. Total discharge for that year was 4.5 billion L (1.2 billion gal). Between 1987 (when fuels fabrication ceased in the 300 Area) and 1994 (when waste discharges ceased), the wastewater consisted of cooling water with small quantities of nonhazardous maintenance and process waste. When the 300 Area Process Trenches were in use, the east and west trenches were used alternately for periods of up to approximately 8 months. The west trench was removed from service in November 1992; the east trench remained in service with an average discharge of 814 L/min (215 gpm). The trenches were administratively isolated from receiving further discharges in December 1994 and were physically isolated in January 1995.

Elevation in NAVD88, *North American Vertical Datum of 1988*.

Figure 2-1. Map of the 300 Area Process Trenches

The 300 Area Process Trenches consisted of two 457 m (1,500 ft) long trenches excavated 3.7 m (12 ft) into the subsurface and separated by an earthen berm. The unlined trenches were excavated into the sandy gravels of the Hanford formation, an open framework, clast supported pebble/cobble/boulder gravel with intercalated, variably thick, sand and silty sand lenses (additional description provided Section 2.4.1, Stratigraphy). The trench bottoms were about 6 m (20 ft) above the average water table elevation (however, the water table elevation varies with river stage, which fluctuates several meters depending on the season and operation of the several dams on the Columbia River). In 1990, the west trench was divided by a berm between the natural depression in the northern end of the trench and the remainder of the trench to the south. The berm was needed to support a bird screen placed over the trench. From 1991 until the site was remediated from 1997 to 1998, the northern 91 m (300 ft) of the original trenches, including the natural depression, were used as an impoundment for low-level radioactive and low-level, mixed waste soil dredged from the southern portions of the trenches.

Administrative controls to prevent disposal of dangerous wastes to the 300 Area Process Trenches were instituted on February 1, 1985. Prior to that time, a variety of chemical waste was included with the wastewater. However, no large quantity of any one waste was included in the process waste. From the beginning of operations in 1975 until October 1993, a continuous, composite sampler was located at the headwall to analyze the wastewater at the point of discharge to the trenches. Subsequently, a sampler located outside the unit analyzed the effluent. In addition, chemical spills are known to have entered the process sewer through 300 Area building floor drains.

In 1991, at the request of the regulatory agency (Ecology), an expedited response action (ERA) was undertaken at the 300 Area Process Trenches (waste site 316-5) to reduce the potential migration of contaminants to groundwater (DOE/RL-91-11). The specific goal was to reduce the measurable level of radiation in the trenches to less than three times the upper tolerance limit of background. The ERA included removing contaminated sediment, using it to fill in the north ends of the trenches, and immobilizing the sediment by covering it with a plastic barrier followed by a layer of clean soil (DOE/RL-92-32). The removal of sediment contaminated with radionuclides also reduced the levels of inorganic constituents remaining in the trenches. Approximately 5,400 m^3 (190,700 ft^3) of sediment was removed and relocated in each trench. About 0.3 m (1 ft) of contaminated soil was removed from the sides and 1.3 m (4 ft) from the bottom of each trench. The less radioactively contaminated sediment (less than 2,000 counts/second) was relocated to the north end of each trench. The more radioactively contaminated sediment (greater than 2,000 counts/sec) was consolidated in the depression located at the northwestern corner of the west trench. The contaminated sediments were isolated from the effluent and then covered with a plastic barrier and a layer of clean aggregate. Results of pre- and post-ERA sampling and analysis of the sediments indicate that the ERA successfully reduced trench contamination at all areas of the trenches except the locations where contaminated sediment was stockpiled. Results of groundwater sampling and analysis after the ERA also showed a drop in concentrations of groundwater contamination.

Remediation of the 300 Area Process Trenches was performed from July 1997 to February 1998 under an integrated RCRA/CERCLA process and included removal and disposal of the site structures (bird screens, head-works, and blockhouse structures) and contaminated sediment that had been previously stockpiled during the 1991 ERA (DOE/RL-98-31). After removal of contaminated soil, clean backfill was added, and site grading and revegetation were performed.

2.2 Regulatory Basis

In 1986, DOE entered into a regulatory order (EPA and Ecology, 1986, EPA Regulatory Order No. 1085-10-07-3008 and Ecology No. DE 86-133). The order mandated interim status groundwater quality assessment monitoring according to 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and WAC 173-303-400, "Interim Status Facility Standards," at the 300 Area Process Trenches.

In May 1987, DOE issued a final rule (10 CFR 962, "Byproduct Material"), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. The hazardous waste components of mixed waste were determined to be subject to Ecology authority to regulate these waste since August 19, 1987.

In May 1989, DOE, EPA, and Ecology signed the Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the 300 Area Process Trenches.

Dangerous waste is regulated under RCW 70.105 ("Hazardous Waste Management") and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the state of Washington under RCRA or RCW 70.105.

In 1994, Ecology issued the Hanford Facility RCRA Permit for the Hanford Site. The 300 Area Process Trenches were included in Part V of the permit, which contains requirements specifically applicable to TSD units that are undergoing closure. Part II, Condition II.F, of the Hanford Facility RCRA Permit specified that a groundwater monitoring program under final status would be subject to the requirements of WAC 173-303-645. A final status compliance monitoring plan was issued in 1995 (WHC-SD-EN-AP-185, Rev. 0).

The first sample set collected under the final status plan showed that downgradient concentrations of *cis*-1,2-DCE, TCE, and uranium exceeded the concentration limits established in the compliance monitoring plan (WHC-SD-EN-AP-185, Rev. 0). WAC 173-303-645(11) requires corrective action activities to reduce contaminant concentrations in groundwater. Remediation of the groundwater was deferred to the CERCLA program, with the corrective action to be integrated with the prescribed 300-FF-5 OU action (groundwater monitoring and ICs) in the 300-FF-5 OU ROD (EPA/ROD/R10-96/143). The monitoring plan was revised in 1996 (WHC-SD-EN-AP-185, Rev. 0A) but continued as a compliance monitoring plan.

The 300 Area Process Trenches (316-5 waste site) were remediated in 1997 and 1998 under an integrated CERCLA/RCRA process. The waste site was reclassified under CERCLA to Closed Out in the Waste Information Database System in May 1998. The 300 Area Process Trenches were closed under a modified closure; that is the soil column was clean closed in 1998 under the Hanford Facility RCRA Permit with requirements for continued corrective action groundwater monitoring (Ecology, 1998). The corrective action plan was included in the 300 Area Process Trenches post-closure plan (DOE/RL-98-31), which states that the CERCLA actions under the 300-FF-5 ROD (EPA/ROD/R10-96/143) constitute the corrective action measures to be taken in accordance with WAC 173-303-645(11). The existing compliance monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) was accepted by Ecology as the corrective action monitoring plan for the 300 Area Process Trenches (Ecology, 1998). The corrective

action groundwater monitoring plan was incorporated into the post-closure plan (DOE/RL-98-31) and the Hanford Facility RCRA Permit. Corrective action groundwater monitoring under WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) continues to this day.

The 300 Area ROD/ROD Amendment (EPA and DOE, 2013) was issued in 2013. Remedies selected for the groundwater COCs (*cis*-1,2-DCE and TCE) in the 300 Area Process Trenches area (300 Area Industrial Complex) include MNA and ICs. MNA will be performed until the concentrations of *cis*-1,2-DCE and TCE meet the cleanup levels. ICs restricting groundwater access and use will be implemented until groundwater cleanup levels are achieved.

In 2015, an evaluation of groundwater COCs was performed for wells identified for monitoring the CERCLA MNA remedy. The evaluation was incorporated into the 300 Area sampling plan that implements the MNA remedy under CERCLA (DOE/RL-2014-42) and was approved by EPA. The evaluation found that TCE had attained the cleanup level identified in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) at each well in the 300 Area network, except for well 399-4-14 (ECF-300FF5-15-0017, *Calculation of Concentration Trends, Means, and Confidence Limits for cis-1,2-Dichloroethene, Gross Alpha, Nitrate, Trichloroethene, Tritium, and Uranium in the 300-FF-5 Operable Unit*, Table 7.4). Based on these results, monitoring for TCE under CERCLA is required at well 399-4-14 only (DOE/RL-2014-42, Table 3.3). Well 399-4-14 does not monitor 300 Area Process Trenches.

2.3 Waste Characteristics

The waste generating processes in the 300 Area that produced liquid waste that, in turn, was sent to the 300 Area Process Trenches via the process sewer, included fuel fabrication process waste, laboratory process waste, unplanned waste releases, and some miscellaneous waste. Highly radioactive liquid waste was generally diverted away from the process sewer and was sent to the 300 Area Radioactive Liquid Waste Sewer. Estimated quantities for the chemicals discharged to the process sewer from 1975 until the implementation of administrative controls in 1985 are listed in Table 2-1. Table 2-2 provides the flow history for the process sewer.

From 1975 (when the trenches entered service) until 1987 (when fuel fabrication essentially ceased), the fabrication of fuel elements was primarily for N Reactor. The primary discharge from fuel fabrication was cooling and rinse water. However, fuel fabrication activities routinely used a broad range of organic and inorganic lubricants, organic solvents, and other chemicals that were discharged to the process sewer (Table 2-3). Fuel fabrication was also a source of approximately 1 percent enriched uranium discharged to the trenches, but was not the source of the types of fission products found in the 300 Area Process Trenches. These radionuclides (other than uranium) originated from the re-anodizing of aluminum spacers used in the reactors before 1975. Most of this waste was intended for the Radioactive Liquid Waste Sewer but occasionally may have entered the process sewer. Additionally, some of these radionuclides were likely deposited in process sewer sludge and could have been released to the 300 Area Process Trenches after 1975 during high sewer flows or deviations from normal pH trends.

The chemical makeup and quantity of 300 Area laboratory waste has not been documented. Although a wide variety of laboratory activities occurred in the 300 Area, laboratory waste is considered similar to fuel fabrication process waste because most of the buildings supported fuel fabrication. Typical laboratory waste could have consisted of standard laboratory cleaners, reagents, organic solvents, neutralizers, and drying agents. These chemical wastes could have been discharged directly to the process sewer through laboratory drains or from the retention process sewer in quantities insignificant to the waste stream.

Table 2-1. Estimated Nonradiological Chemical Waste Inventory for the 300 Area Process Trenches

Total of Intermittent Discharges of Dangerous Chemicals Ending February 1, 1985[a,b]		Larger Discharges[c] Continuing until September 1986[d]		Total of Larger Discharges[e] (1975 to 1986)
Less than 1 g	Less than 1 kg			
Ammonium Biofluoride	Benzene	Copper	= 30 kg/mo[f]	3,960 kg
Antimony	Carbon Tetrachloride	Detergents	≤30 kg/mo[f]	3,460 kg
Arsenic	Chromium	Ethylene Glycol	≤200 L/mo[f]	26,400 L
Barium	Chlorinated Benzenes	Heating Oil	= 300 L[g]	300 L
Cadmium	Formaldehyde	Hydrofluoric Acid	= 100 kg/mo[f]	13,200 kg
Dioxine	Formic Acid	Nitrates	≤2,000kg/mo[f]	264,000 kg
Dioxin	Hexachlorophene	Nitric Acid	≤300 L/mo[f]	39,600 L
Hydrocyanic Acid	Kerosene	Paint Solvents	≤100 L/mo[f]	13,200 L
Pyridine	Lead	Tetrachloroethene	= 450 L[g]	450 L
Selenium Compounds	Methyl Ethyl Ketone	Photo Chemicals	≤700 L/mo[f]	92,400 L
Thiourea	Mercury	Sodium Chloride	= 75 tons/yr[f]	825 Tons
Miscellaneous Laboratory Chemicals	Sulfuric Acid	Sodium Hydroxide	≤300 L/mo[f]	39,600 L
	Tetrachloroethene	Uranium	= 20 kg/mo[f]	2,640 kg
	Toluene			
	Tri-butyl-phosphate			
	1,1,1-trichlorothane			
	Trichloroethene			
	Xylenes			

Reference: Adapted from DOE/RL-91-11, *Expedited Response Action Proposal for the 316-5 Process Trenches.*

a. February 1, 1985 is the date of administrative controls disallowing discharge of dangerous waste to the process sewer.

b. Includes organics that were not analyzed for by process sewer effluent sampling.

c. These discharges, except for the spills, were relatively continuous.

d. September 1986 was the approximate end of fuel fabrication activities.

e. Total is monthly average discharge times 12 (months per year) times 11 (operating year from March 1975 to September 1986).

f. Monthly or annual quantity is an average over a 17-month period (February 1985 to September 1986).

g. Known spills.

Table 2-2. Flow History for the 300 Area Process Trenches

Year	Amount Discharged (Millions of Liters)	Liters/Minute
1975	682	1,298
1976	3,447	6,554
1977	1,894	3,601
1978	1,894	3,601
1979	4,545	8,642
1980	3,180	6,050
1981	3,218	6,122
1982	3,218	6,122
1983	3,445	6,554
1984	3,520	6,698
1985	3,558	6,770
1986	3,407	6,482
1987	3,255	6,194
1988	1,628	3,097
1989	1,893	3,601
1990	1,968	3,745
1991	1,287	2,449
1992	568	1,080
1993	416	792
1994	379	720

Reference: PNNL-13645, *300 Area Process Trenches Groundwater Monitoring Plan.*

Table 2-3. Fuel Fabrication Chemicals and Radionuclides

Chemicals Routinely Used in Fuel Fabrication	Radionuclides Generated by Fuel Fabrication
Chromic Acid	Scandium-46
Chromium Trioxide	Chromium-51
Copper Sulfate	Cobalt-58
Hydrofluoric Acid	Iron-59
Nitric Acid	Cobalt-60
Oxalic Acid	Zinc-65
Phosphoric Acid	Zirconium/Niobium Isotopes
Potassium Nitrite	Cesium-137
Sodium Aluminate	Promethium-147
Sodium Bisulfate	Thorium-234
Sodium Carbonate	Uranium Isotopes
Sodium Dichromate	Plutonium Isotopes
Sodium Fluorosilicate	
Sodium Gluconate	
Sodium Hydroxide	
Sodium Nitrate	
Sodium Nitrite	
Sodium Pyrophosphate	
Sodium Silicate	
Sulfuric Acid	
Trichloroethene	

Reference: DOE/RL-88-31, *Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1 Operable Unit, Hanford Site, Richland, Washington.*

Chemical spills are known to have entered the process sewer through 300 Area building floor drains. The majority of these releases were spent uranium contaminated acid etch solutions. Other unplanned releases to the process sewer system include two spills of tetrachloroethene (PCE) in 1982 (455 L [120 gal]) and 1984 (76 L [20 gal]), and two releases of ethylene glycol in April 1993 (1,364 L [360 gal]) and October 1993 (7.6 L [2 gal]).

While the 300 Area Process Trenches were in operation, some of the facilities in the 300 Area connected to the process sewer performed activities related to reactor operations, irradiated fuel examinations, chemical separations processes, photographic processing, and waste management. Other facilities also supported such activities as peaceful uses of plutonium, reactor fuels development, liquid metal technology, environmental remediation technology development, and life science programs. Although such facilities may have contributed small quantities of radioactive or dangerous waste to the process sewer, trench soil analytical results indicate that their contribution to the waste stream and to subsequent trench soil and potential groundwater contamination is insignificant compared to that of fuel fabrication.

2.4 Geology and Hydrogeology

The geology and hydrogeology of the 300 Area Industrial Complex and 300-FF-5 OU, including the region of the 300 Area Process Trenches, are described in detail in the following documents:

- DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*
- PNNL-16435, *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*
- PNNL-17666, *Volatile Organic Compound Investigation Results, 300 Area, Hanford Site, Washington*
- PNNL-22048, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*

2.4.1 Stratigraphy

Figure 2-2 summarizes the general stratigraphy at the Hanford Site. The stratigraphic units that underlie the 300 Area Industrial Complex, from youngest to oldest, are the eolian surficial deposits and the Hanford formation and Ringold Formation sediments overlying the Columbia River Basalt Group.

- Eolian deposits (Holocene Age) - the most recently deposited sediment is a discontinuous veneer containing eolian sand and/or anthropogenic backfill of previously excavated sediment. These deposits generally overlie the 300 Area Industrial Complex, with a typical thickness of 1 to 6 m (3.3 to 19.7 ft).
- Hanford formation (Pleistocene Age) – equivalent to hydrostratigraphic unit (HSU) 1. The Hanford formation cataclysmic flood deposits are three facies subunits (silt dominated, sand dominated, and gravel dominated), which grade into one another vertically and laterally. In the 300 Area Industrial Complex the Hanford formation is persistently the gravel dominated lithostratigraphic sequence (subunit H1) that typically ranges in thickness from 12 to 24 m (40 to 80 ft). Subunit H1 is coarse-grained, basalt-rich, clast supported, open framework, sandy gravel with variable silt/clay content. As a result, the Hanford formation permeability is generally several orders of magnitude greater than the underlying Ringold Formation. Therefore, the contact between these two highly contrasting stratigraphic units may act as a distinct hydrologic boundary.
- Ringold Formation Unit E and Lower Mud (Miocene Age) – equivalent to hydrostratigraphic unit (HSU) 5 and HSU8, respectively. The gravel dominated Ringold Formation upper coarse unit (Unit E) overlies the Ringold Formation lower mud unit. Unit E is up to 24 m (80 ft) thick and consists of pebbles and cobbles compacted within a matrix of fine- to medium-grained sand with silt. Up to 24 m (80 ft) of Ringold Formation lower mud unit fine-grained sediments overlie the basalt. These low-permeability sediments vary in grain size among clay, silt, and fine sand. This unit forms an aquitard beneath the unconfined aquifer system. The Ringold Formation upper fine member of Taylor Flat, which may be equivalent to the Ringold upper mud unit defined in the 100 Areas, is not present beneath the 300 Area and was most likely removed from the area by paleo-flood and historical River erosional forces.

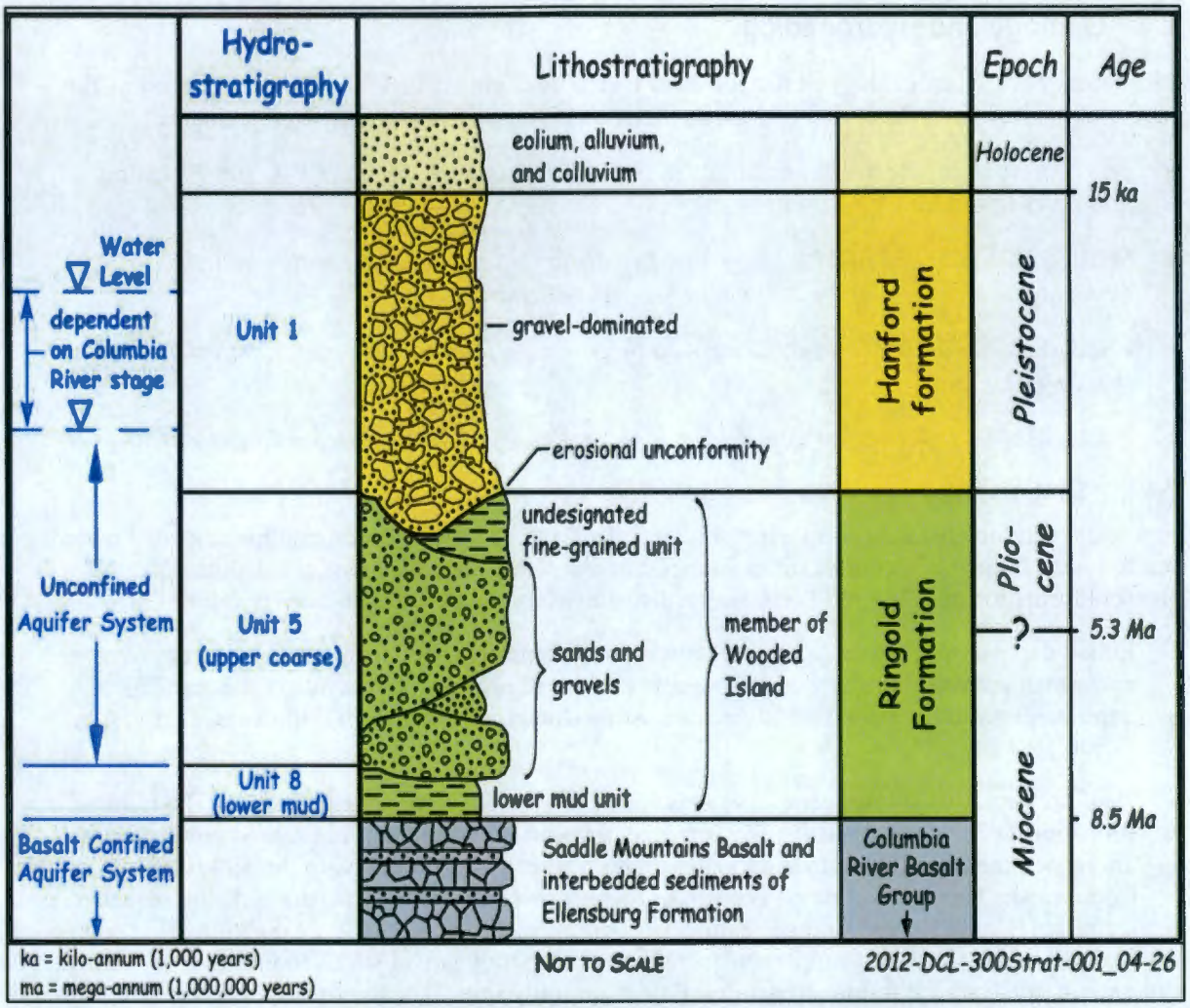


Figure 2-2. Stratigraphy of the 300 Area

A relatively fine-grained interval of Ringold Formation silt and fine sand lies at or near the top of Unit E over portions of the 300 Area Industrial Complex. The finer-grained interval locally creates an aquitard that influences the flow of groundwater within key, critical areas of the 300 Area Industrial Complex. The distribution and thickness of the finer-grained unit is highly variable across the 300 Area Industrial Complex. It is thickest (up to 10 m [33.5 ft]) as a dome-shaped feature south and east of the former South Process Pond. Borehole data suggest that this unit is not present underlying the 300 Area Process Trenches, but the data are limited. Depth discrete aquifer testing and depth discrete groundwater results from the 300-FF-5 OU Limited Field Investigation wells (PNNL-16435) indicate that uranium contaminated groundwater is significantly elevated in the saturated Hanford portion of the unconfined aquifer but drops significantly below the Ringold Formation contact within the fine-grained interval.

Geologic cross sections, which include selected wells in the 300 Area Process Trenches monitoring network and surrounding area, present the approximate stratigraphy underlying and adjacent to the site (Figures 2-3 and 2-4).

2.4.2 Hydrogeology

The vadose zone comprises recent and backfill materials and unconsolidated gravels and sand of the Hanford formation. In the 300 Area Industrial Complex, the average thickness of the vadose zone is 10 m (33 ft). However, the vadose zone thickness varies with the seasonal stages of the Columbia River and distance inland from the river. Rising groundwater elevations resulting from higher Columbia River stages seasonally saturate deeper portions of the vadose zone, while lower river stages result in falling groundwater elevations that dewater these same deeper portions of the vadose zone. These fluctuating groundwater elevations create the periodically rewetted zone (Figure 2-5). Generally, wells adjacent to the river within the 300 Area Industrial Complex show higher variation in response to river stage changes than wells located further from the shoreline (PNNL-22048, Section 2.4.3).

The unconfined aquifer occurs in the highly permeable, gravel dominated Hanford formation and in the underlying, less permeable sands and gravels of the Ringold Formation upper coarse unit (Ringold Formation unit E). Paleochannels carved into Ringold Formation sediments are filled with Hanford formation gravels that provide preferential pathways for groundwater flow and for intrusion of river water during periods of high river stage (DOE/RL-2010-99, Section 4.4.4.3) (Figure 2-6). The Ringold Formation lower mud unit is a confining layer (i.e., aquitard at the base of the unconfined aquifer) and is characterized by very low-permeability fine-grained sediment. This hydrologic unit prevents further downward movement of groundwater contamination to the deeper aquifers. The thickness of the unconfined aquifer along the Columbia River shoreline is about 25 m (80 ft).

2.4.3 Groundwater Flow Interpretation

Groundwater in the unconfined aquifer discharges to the Columbia River via upwelling through the riverbed and riverbank seeps. The flow from the unconfined aquifer is very low, compared to the flow of the river. Because the river stage fluctuates up and down, flow beneath the shoreline oscillates back and forth, with river water intruding into the unconfined aquifer and mixing with groundwater at times. When the river stage drops quickly to a low elevation, riverbank seeps appear. The rise and fall of the river stage create a dynamic zone of interaction between groundwater and river water, affecting groundwater flow patterns, contaminant transport rates, groundwater geochemistry, contaminant concentrations, and contaminant attenuation rates.

Groundwater flow velocities beneath the 300 Area Process Trenches were estimated to be 17 m/day (56 ft/day) in March 2014 and 13 m/day (43 ft/day) in June 2014 (DOE/RL-2015-07, Table B.1). Because the hydraulic gradients change direction in response to river stage, which fluctuates on seasonal and multiyear cycles, groundwater flow is not always directed toward the river. The flow direction beneath the 300 Area Process Trenches was estimated to be south-southeast in March 2014 and southwest in June 2014 (DOE/RL-2015-07, Table B-1) (Figure 2-7). Accordingly, groundwater flow direction beneath the 300 Area Process Trenches is predominantly to the south-southeast when the river stage is low (typical throughout most of the year). However, when the river stage is high (typically late spring and early summer), groundwater flow direction beneath the trenches may change to south-southwest. Figure 2-8 presents the 2014 regional water table map.

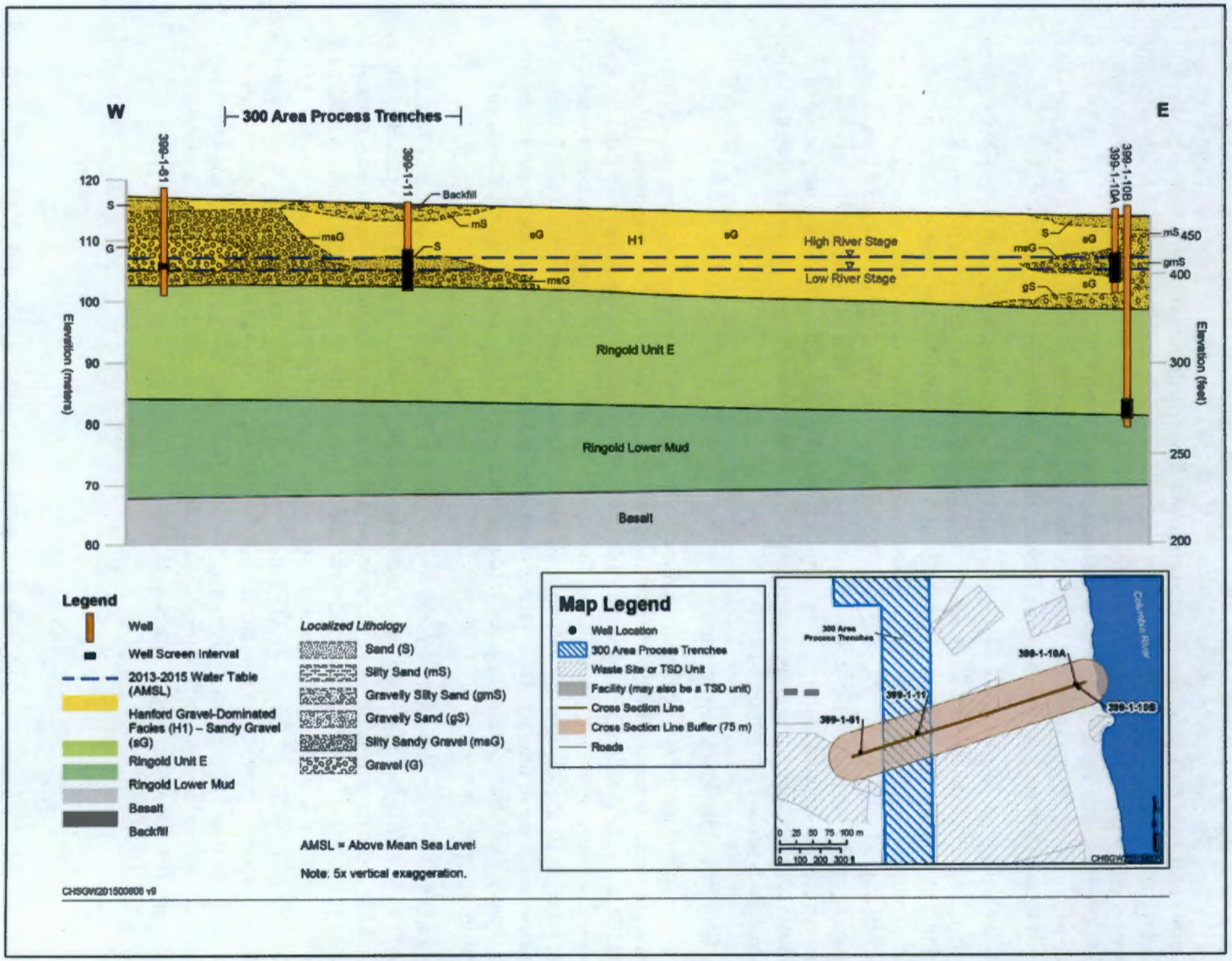


Figure 2-3. West-East Geologic Cross Section Showing the Stratigraphy Underlying the 300 Area Process Trenches

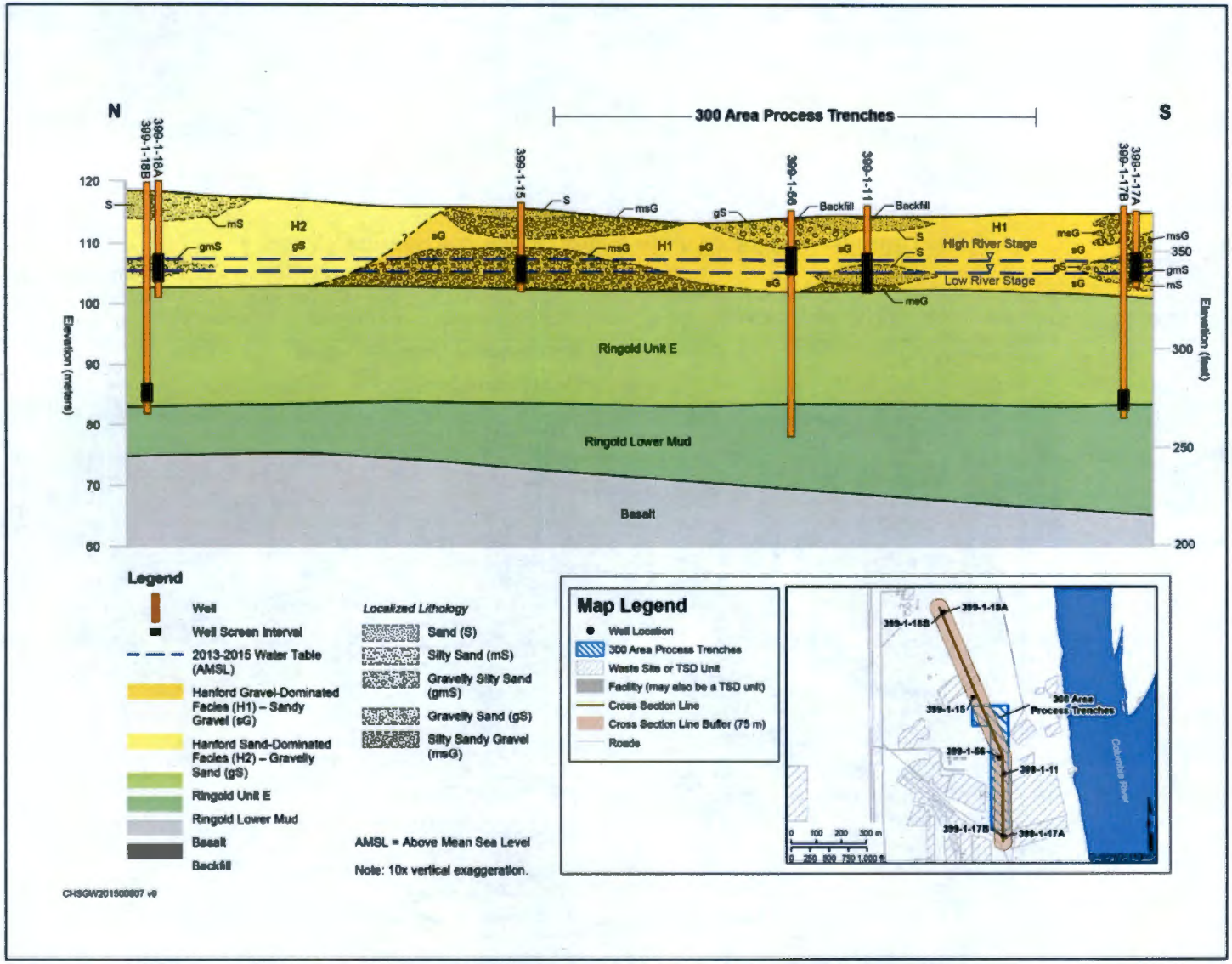
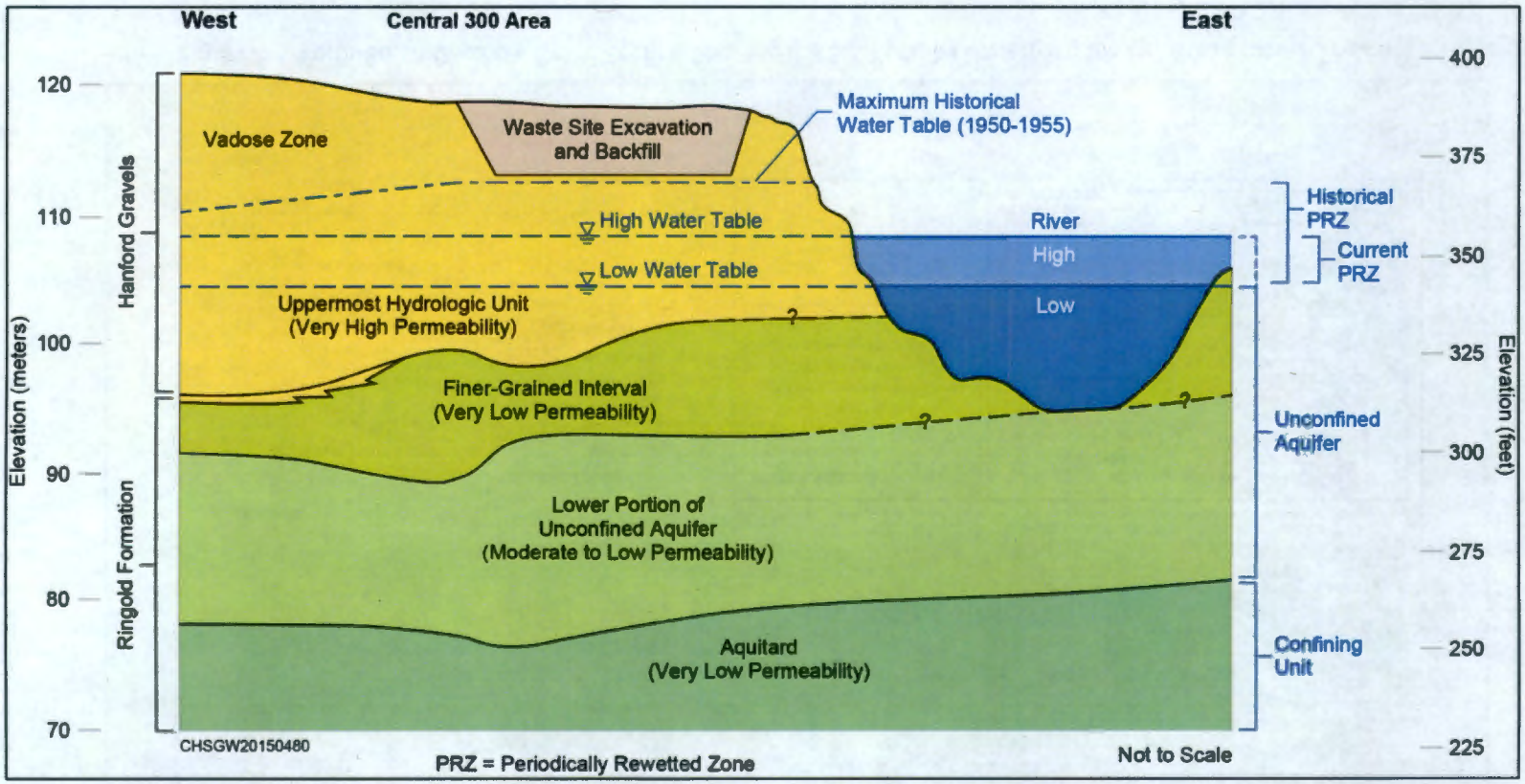
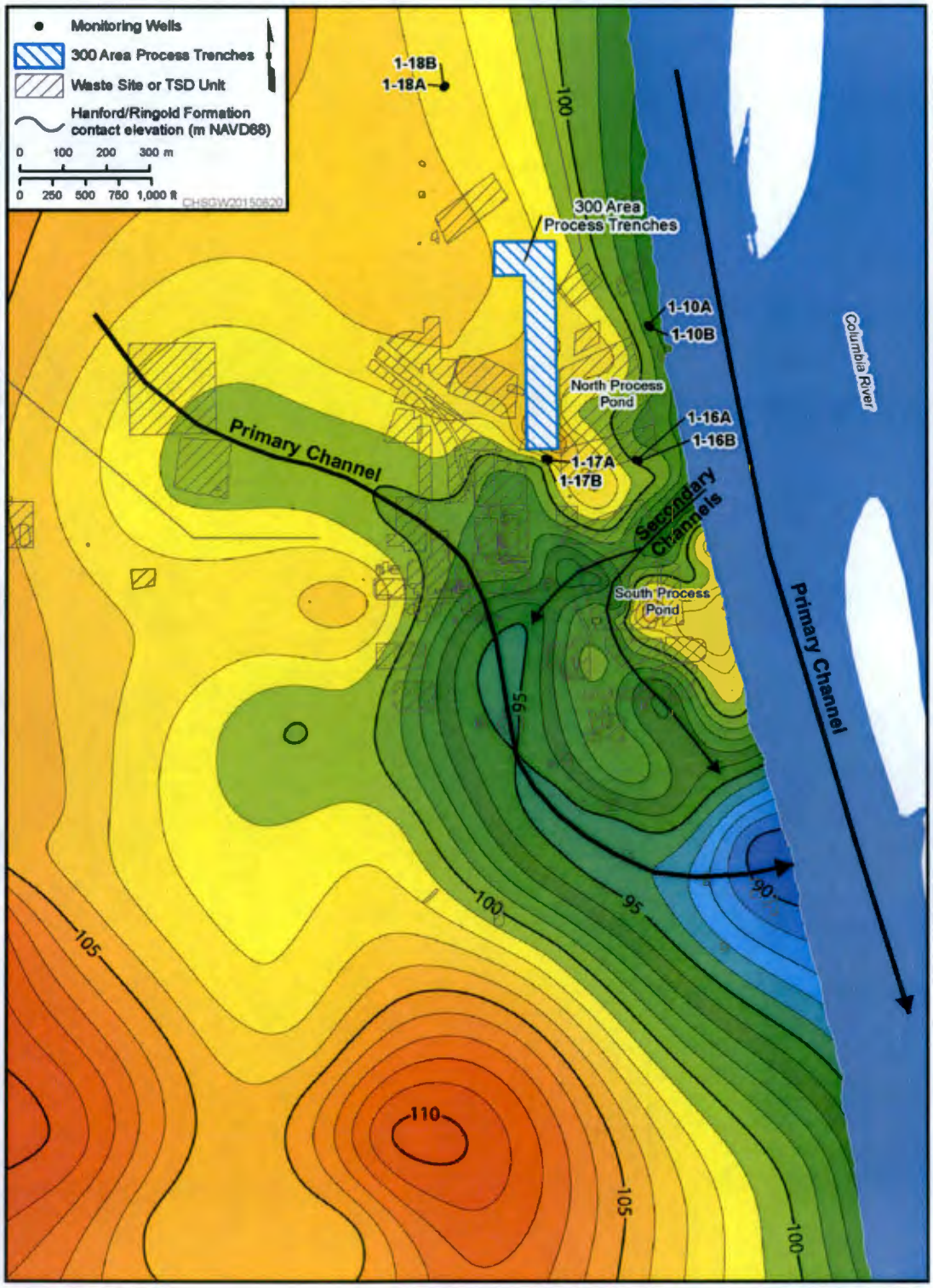


Figure 2-4. North-South Geologic Cross Section Showing the Stratigraphy Underlying the 300 Area Process Trenches



Sources: EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*. Modified from DOE/RL-2011-47, *Proposed Plan for Remediation of the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*.
Elevation in NAVD88, *North American Vertical Datum of 1988*.

Figure 2-5. Principal Subsurface Features within the 300 Area Industrial Complex



Modified from PNNL-22048, *Updated Conceptual Model for the 300 Area Uranium Groundwater Plume*. Elevation in NAVD88, *North American Vertical Datum of 1988*.

Figure 2-6. Locations of Paleochannels in the Ringold Formation Upper Surface

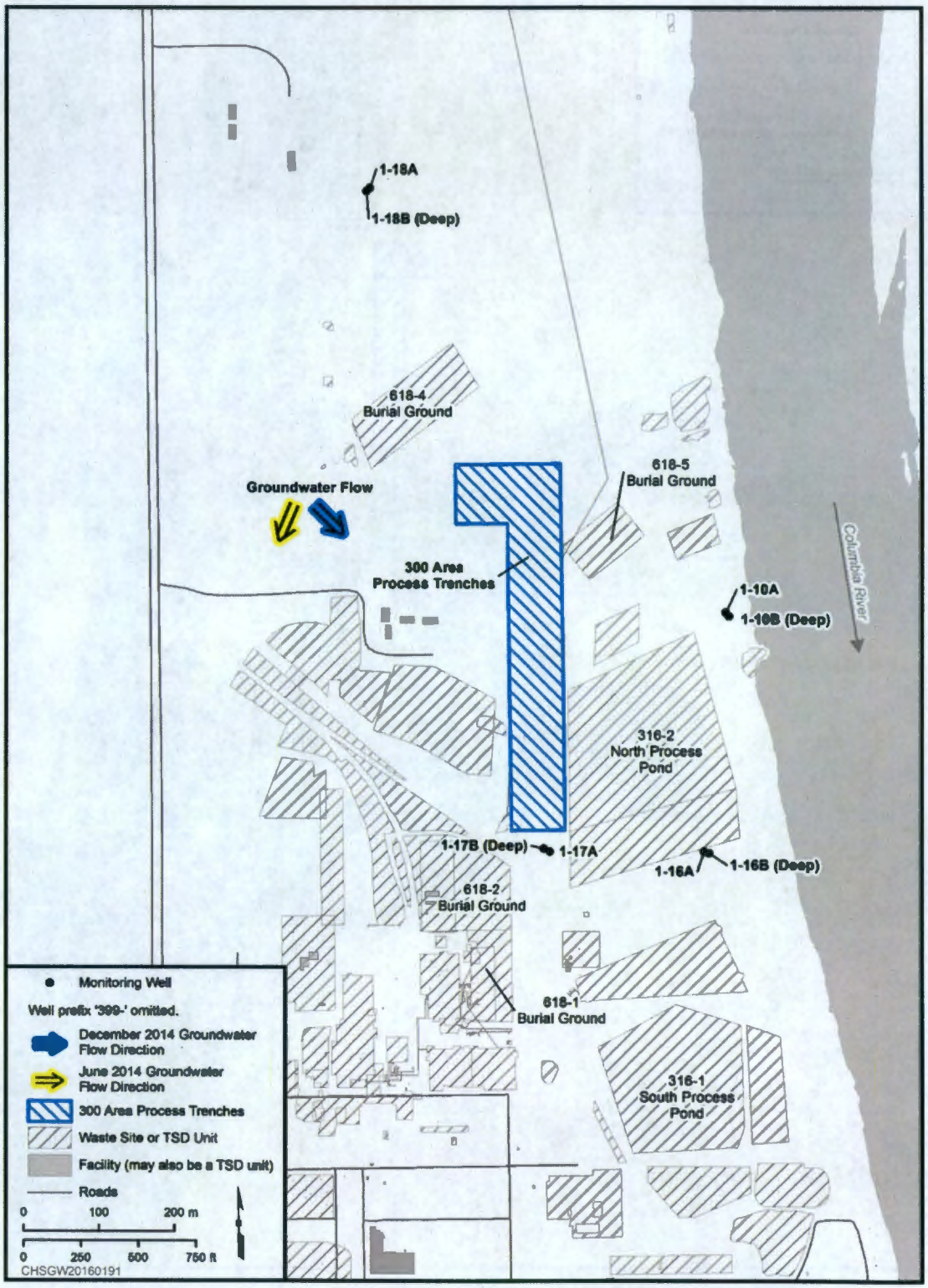
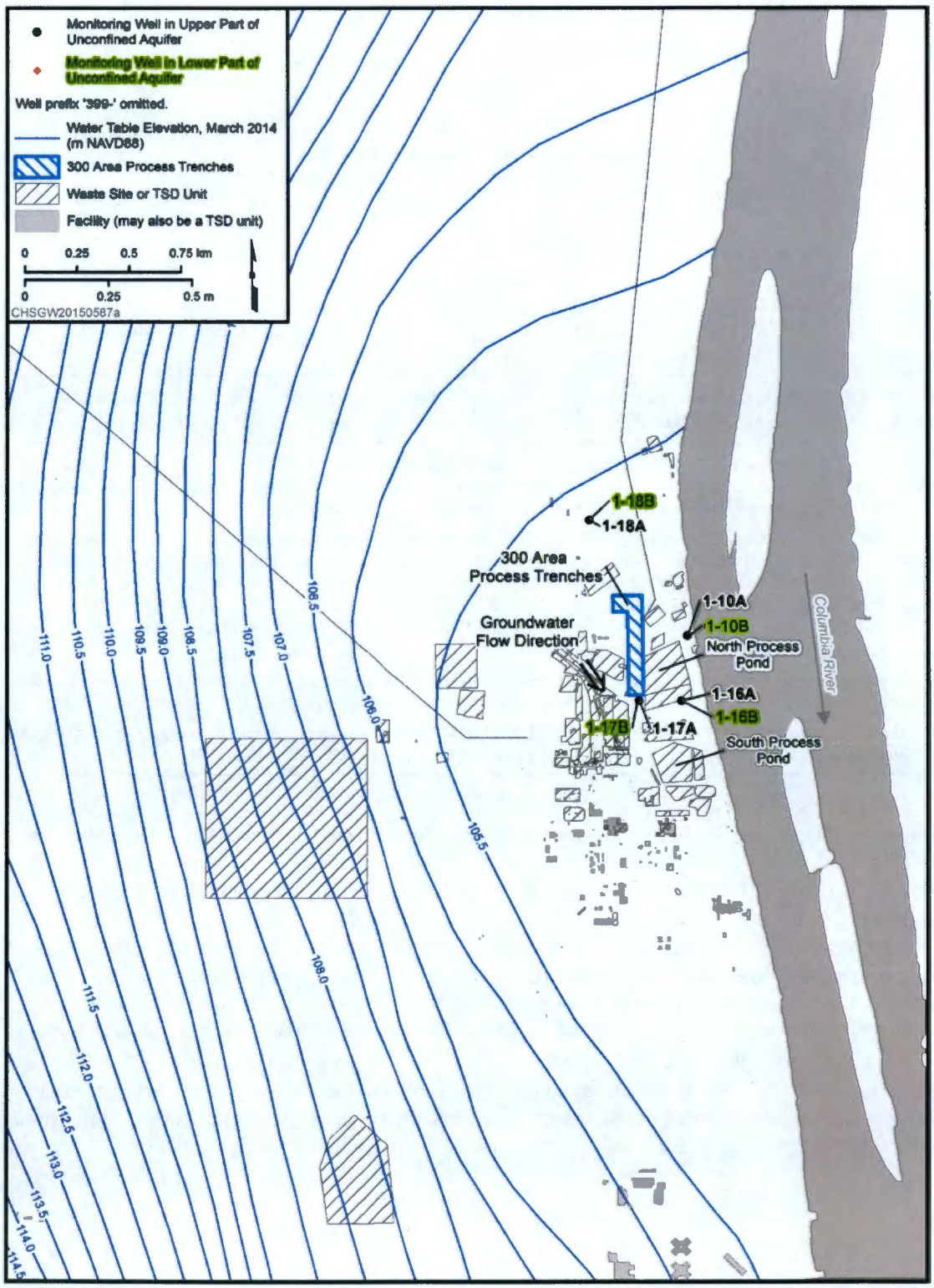


Figure 2-7. Groundwater Flow Direction at the 300 Area Process Trenches



Elevation in NAVD88, *North American Vertical Datum of 1988*.

Figure 2-8. Groundwater Contour Map for 2014

2.5 Summary of Previous Groundwater Monitoring

Table 2-4 lists the previous groundwater monitoring plans implemented at the 300 Area Process Trenches.

Table 2-4. Previous Monitoring Plans

Document	Date Issued	Monitoring Program
Hazardous Waste Ground-Water Monitoring Plan (Appendix E of DOE, 1985, *Closure/Post-Closure Plan 300 Area Process Trenches*)	1985	Interim Status Compliance[a]
PNL-6671, *Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches*	1988	Interim Status Compliance[a]
WHC-SD-EN-AP-185, *Groundwater Monitoring Plan for the 300 Area Process Trenches*[b]	1995 (Rev. 0) 1996 (Rev. 0A)	Final Status Compliance[c] Final Status Corrective Action[d]

a. The compliance monitoring program was developed to satisfy the requirements in 40 CFR 265.90, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Applicability," and WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards."

b. The compliance monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) was accepted by the Washington State Department of Ecology in 1998 as the corrective action monitoring plan without revision (Ecology, 1998, "Acceptance of Certification of the 300 Area Process Trenches Clean Closure of the Soil Column and Ground Water Corrective Action Requirements"). The requirements identified in WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) were incorporated in WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*.

c. The compliance monitoring program satisfied the requirements of WAC 173-303-645(10), "Dangerous Waste Regulations," "Releases from Regulated Units," "Compliance Monitoring Program."

d. The compliance monitoring program under WAC 173-303-645(10) also satisfies the requirements for a corrective action monitoring program under WAC 173-303-645(11), "Corrective Action Program."

Groundwater monitoring has been performed at the 300 Area Process Trenches since 1975 with the first major study collecting monthly samples at 29 wells during 1977 (PNL-2949, *Geology and Groundwater Quality Beneath the 300 Area, Hanford Site, Washington*). Due to known groundwater contamination, a groundwater monitoring program (presented in Appendix E of DOE, 1985, *Closure/Post-Closure Plan 300 Area Process Trenches*) began in June 1985. The program was designed as an alternate groundwater monitoring program due to known or suspected contamination of the uppermost aquifer. The well network was comprised of 16 wells (399-1-1, 399-1-2, 399-1-3, 399-1-4, 399-1-5, 399-1-6, 399-1-7, 399-1-8, 399-2-1, 399-3-7, 399-3-10, 399-4-1, 399-4-7, 399-8-2, 699-S19-E13, and 699-S30-E15A [PNL-6671]) (Figure 2-9). Samples were collected monthly and analyses included temperature, pH, conductivity, coliform, metals, anions, volatile and semivolatile organic compounds, selected organic constituents, pesticides, herbicides, total organic halogens, total organic carbon, ammonium ion, hydrazine, total alpha-emitters, total beta-emitters, gamma emitters, radium, uranium, and strontium-90.

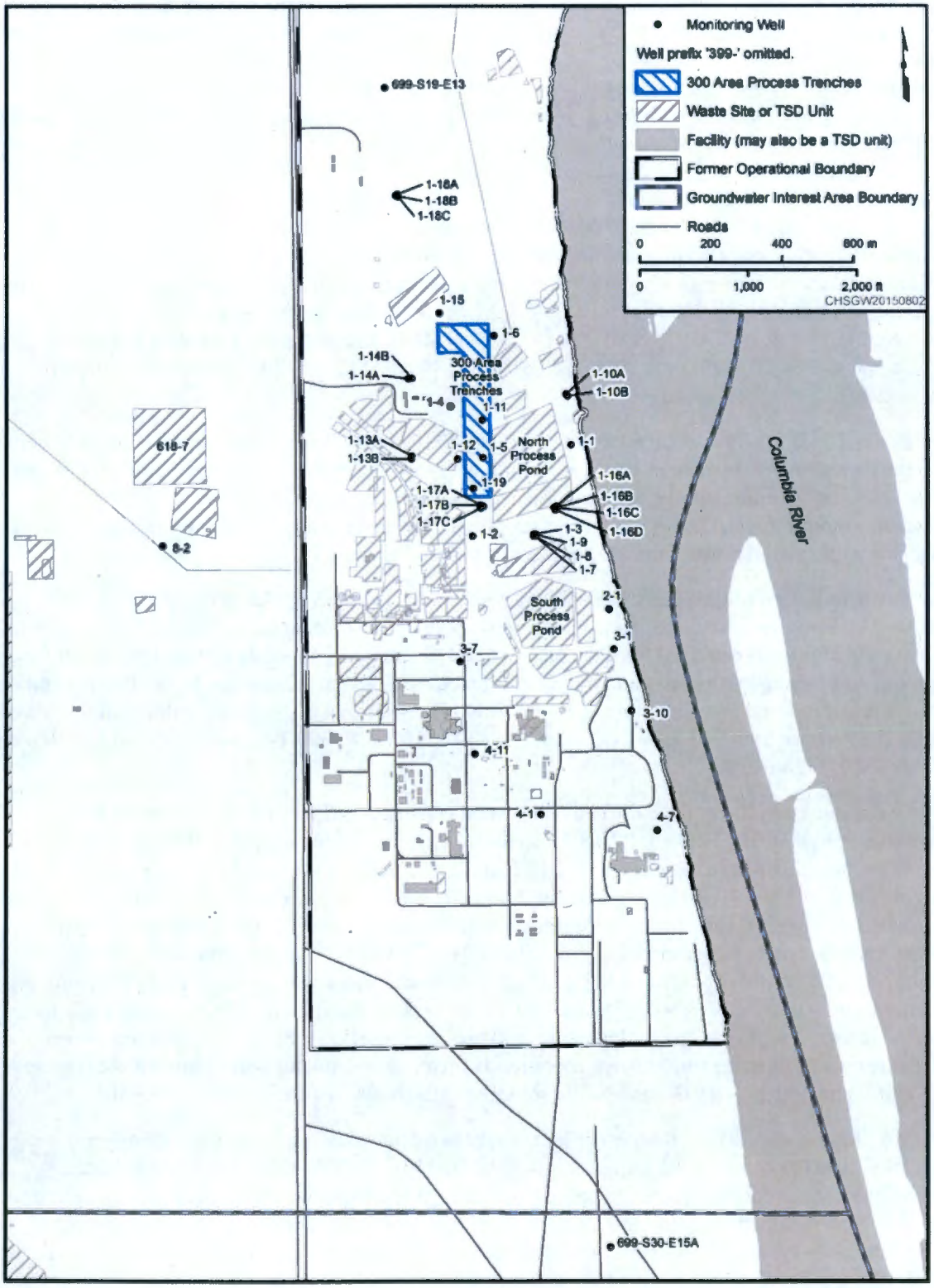


Figure 2-9. Groundwater Wells used in the 300 Area Process Trenches Monitoring Networks

The monitoring program was intended to meet 40 CFR 265.90(d), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and WAC 173-303-400 but was determined to have an inadequate well network by Ecology and resulted in a regulatory order (EPA and Ecology, 1986). In response to the order (Ecology and EPA, 1986), the 300 Area Process Trenches was placed in an interim status groundwater quality assessment level monitoring plan based on the finding that groundwater quality in the 300 Area had been impacted by the 300 Area Process Trenches. A revision to the 1985 groundwater monitoring plan, PNL-6671, was first issued in 1986 (as described in PNL-6716 and WHC-SD-EN-AP-185, Rev 0). Nineteen new monitoring wells were installed in 1986 and 1987 to enhance the understanding of the hydrogeology and characterize the contamination (PNL-6671). These included five well clusters, which included wells at the upper and lower portions of the unconfined aquifer ("A" and "B" wells, respectively) and at some locations, wells in the confined aquifer ("C" well) and in a basalt aquifer ("D" well). The cluster wells included 399-1-16ABCD, 399-1-17ABC, 399-1-18ABC, 399-1-14AB, and 399-1-10AB (PNL-6716). New single wells included 399-1-9, 399-1-11, 399-1-12, 399-1-13, 399-1-15, 399-1-19, and 399-4-11 (PNL-6716) (Figure 2-9).

Monitoring data from 1986 to 1988 (reported in PNL-6716) found that most of the analytes were below regulatory standards. Constituents that were regularly reported above the detection limit included gross alpha, gross beta, barium, nitrate, sodium, iron, sulfate, chloride, copper, ammonium, vanadium, potassium, chloroform, and methyl chloride. Chromium, mercury, selenium, and fluoride were reported as being above the interim primary drinking water standard at least once.

After characterization of the 300 Area Process Trenches, the monitoring plan was revised in 1988 (PNL-6671). Samples were collected from the network of 35 monitoring wells. During 1989 to 1994, wells were periodically removed from the network and the sampling schedule changed from monthly, to quarterly, and eventually to semiannually as the characterization information had been obtained and the 1991 ERA had reduced contamination in the trenches. The well network eventually dropped to 11 wells including 399-1-10, 399-1-11, 399-1-12, 399-1-14, 399-1-16A&B, 399-1-17A&B, 399-1-18A, 399-2-1, and 399-3-10 (Figure 2-9).

Volatile organic analysis results indicated that several constituents (PCE, toluene, xylene, benzene, TCE, chloroform, ethylbenzene, and *cis*-1,2-DCE) were detected downgradient of the 300 Area Process Trenches during this period. However, only TCE and *cis*-1,2-DCE were consistently above the drinking water standard of 5 and 70 µg/L, respectively. The well showing the exceedances of TCE and *cis*-1,2-DCE was 399-1-16B. Uranium continued to be detected in several wells near the 300 Area Process Trenches and was correlated to gross alpha. The ERA in 1991 reduced the concentrations of uranium significantly in the network wells such that uranium exceeded the then 20 µg/L EPA-proposed guidance in only two wells (399-1-17A and 399-1-10A). (Note: the final rule for the uranium drinking water standard, 30 µg/L, was promulgated in 2000 and became effective in 2003.) Concentrations of iron and manganese in filtered samples were consistently higher than drinking water standard for two wells (399-1-16B and 399-1-17B). Both wells are screened at the bottom of the unconfined aquifer.

The 1994 Hanford Facility RCRA Permit for the Hanford Site required groundwater monitoring programs under final status to comply with requirements of WAC 173-303-645. A final status compliance monitoring program for the 300 Area Process Trenches (WHC-SD-EN-AP-185, Rev. 0) was issued in 1995. The plan included sampling from a network of four well pairs. Three pairs are downgradient (399-1-10A, 399-1-10B, 399-1-16A, 399-1-16B, 399-1-17A, and 399-1-17B) and one pair is upgradient (399-1-18A and 399-1-18B). Samples were collected semiannually with four independent samples per event, for a total of eight samples per year. Analysis was performed for gross alpha, gross beta, uranium, *cis*-1,2-DCE, TCE, iron, manganese, and field parameters (pH, conductivity, turbidity, and temperature).

The first sample series began in December 1996 and showed that downgradient concentrations of *cis*-1,2-DCE, TCE, and uranium exceeded concentration limits identified in the monitoring plan (WHC-SD-EN-AP-185, Rev. 0). Rev. 0A of the monitoring plan, issued in 1996, specified analysis for uranium, TCE, *cis*-1,2-DCE, and field parameters (pH, conductivity, turbidity, and temperature). Thallium, PCBs, chrysene, and benzo(a)pyrene were included in the Rev. 0A plan for a two-year monitoring period due to concern about dangerous waste leaching from the relocated sediment stockpiled at the northern ends of the trenches. Additionally, iron and manganese were monitored as part of a follow-up geochemical investigation. WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) was accepted without change as the corrective action monitoring plan, as required by WAC 173-303-645(11), in 1998 (Ecology, 1998).

In 2001, a proposed corrective action monitoring plan was prepared (PNNL-13645). However, the Hanford Facility RCRA Permit was not updated with the proposed monitoring plan, and WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) remained the corrective action monitoring plan.

Monitoring results since 1997 for the dangerous wastes *cis*-1,2-DCE and TCE within the well network are presented in Appendix D. For both constituents, exceedances of the concentration limit or cleanup level occur in a single well: 399-1-16B. TCE last exceeded the cleanup level of 4 µg/L established in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) in 1999.

In 2015, an evaluation of groundwater COCs in wells identified for monitoring of the CERCLA MNA remedy was performed. The evaluation found that TCE had attained the cleanup level identified in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) at each well in the 300 Area network, except for 399-4-14 (ECF-300FF5-15-0017). Based on these results, monitoring for TCE under CERCLA is required only at well 399-4-14, which does not monitor the 300 Area Process Trenches. Evaluation of *cis*-1,2-DCE found that concentrations in well 399-1-16B would not meet cleanup levels by year 2050 (ECF-300FF5-15-0017). *Cis*-1,2-DCE concentrations in this well have exceeded the concentration limit throughout the corrective action monitoring period with detections ranging from 95 to 280 µg/L. Monitoring for *cis*-1,2-DCE and TCE will continue at the 300 Area Process Trenches under the Hanford Facility RCRA Permit.

In 1987, elevated concentrations of PCE and its biodegradation products, TCE and *cis*-1,2-DCE, were observed in well 399-1-16B. PCE concentrations subsequently declined to less than the drinking water standard prior to issuance of the compliance monitoring plan in 1995 (WHC-SD-EN-AP-185, Rev. 0). The source for these concentrations has been suggested to be the 300 Area Process Trenches because these trenches are upgradient of well 399-1-16B, spills (530 L [140 gal]) of PCE were discharged to the trenches in 1982 and 1984, and the concentrations were detected and monitored by the 300 Area Process Trenches groundwater monitoring network. Numerical modeling for these constituents was performed in Appendix F of DOE/RL-2010-99 (ECF-300FF5-11-0152, *VOC Modeling in Support of 300 Area FF-5 RI/FS Document*) to evaluate the contamination and determined a different outcome.

The numerical modeling had two objectives. The first objective was to determine whether it was plausible that PCE-dense nonaqueous phase liquid (DNAPL) discharged to the 300 Area Process Trenches would infiltrate the Hanford formation and penetrate the Ringold Formation Unit E. The second objective was to assess the plausibility that PCE-DNAPL trapped in Unit E beneath the 300 Area Process Trenches could be the source of PCE, TCE, and *cis*-1,2-DCE concentrations observed in well 399-1-16B. Results of the numerical modeling indicate that it is plausible the PCE infiltrating beneath the 300 Area Process Trenches would penetrate Unit E of the Ringold Formation. However, modeling results also indicate that it does not appear plausible that the source for the concentrations observed in well 399-1-16B was the 300 Area Process Trenches.

PCBs, benzo(a)pyrene, and chrysene were not detected the 300 Area Process Trenches groundwater monitoring network during the required two years of monitoring (1996 to 1998) and do not require further monitoring (PNNL-11470, *Hanford Site Groundwater Monitoring for Fiscal Year 1996*; PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*; and PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*). Thallium was detected during the required two years of monitoring. However, thallium was determined to be naturally occurring based on evaluation in DOE/RL-2010-99.

In 2014, elevated iron and manganese concentrations in the deep unconfined aquifer were evaluated using groundwater data from 1995 to 2014 at wells 399-1-16A, 399-1-16B, 399-1-17A, and 399-1-17B (ECF-300FF5-14-0044, Section 8). The evaluation found oxidizing conditions are present in shallower portions of the unconfined aquifer. However, deeper groundwater contains very low levels of dissolved oxygen, low or non-detectable nitrate concentrations, notably lower oxidation-reduction potential, and evidence of reductive dechlorination of chlorinated organic compounds. The differences in the observed reduction-oxidation-sensitive parameters between the shallow and deep portions of the unconfined aquifer are consistent with the higher concentrations of dissolved iron and manganese observed in the deeper groundwater at wells 399-1-16B and 399-1-17B. The elevated iron and manganese levels are likely produced by the partial reductive dissolution of iron and manganese hydroxides and oxides in the matrix of the upper Ringold Formation.

Geochemical modeling using PHREEQC, a geochemical modeling computer code developed by the United States Geological Survey, was conducted to determine whether the iron and manganese concentrations in wells 399-1-16B and 399-1-17B are consistent with equilibrium between the groundwater in the deep unconfined aquifer and reduced iron and manganese minerals such as siderite and rhodochrosite. Geochemical modeling under the assumed reduction-oxidation conditions indicate that the samples collected from 399-1-16B are saturated with calcite, amorphous ferric hydroxide, and rhodochrosite, and are slightly under-saturated to saturated with siderite. The results for 399-1-17B indicate saturated conditions with calcite, amorphous ferric hydroxide, siderite and rhodochrosite. The differences between the shallow and deep groundwater in the unconfined unit suggest that the elevated iron and manganese concentrations observed in wells 399-1-17B and 399-1-16B are consistent with iron-reducing conditions in the deeper parts of this unit. Although the modeling results cannot definitively demonstrate that the reducing conditions are naturally occurring, it supports this conclusion by demonstrating that the elevated iron and manganese concentrations observed in the deep aquifer since 1995 are consistent with naturally occurring iron and manganese minerals commonly found in uncontaminated reducing aquifers (ECF-300FF5-14-0044).

Historical releases of readily biodegradable organics (e.g., benzene, toluene, ethylbenzene, and xylenes [BTEX]) cannot be absolutely precluded as a cause for the development of more reducing conditions in the deeper unconfined aquifer. However, this is not likely due to the low observed BTEX concentrations and long term stability of the reducing conditions in the deeper aquifer, while much more oxidizing conditions have been maintained in the shallower part of the unit (ECF-300FF5-14-0044).

Based on the very low concentrations of readily biodegradable (non-chlorinated) anthropogenic organic compounds in the shallow or deep unconfined aquifer over the last 20 years, the weight of the evidence suggests that the slightly to moderately elevated levels of iron and manganese observed in wells 399-1-16B and 399-1-17B do not reflect the effects of contamination released to the aquifer (ECF-300FF5-14-0044). Because the evidence suggests that elevated iron and manganese are due to naturally occurring reducing conditions and are not attributable to 300 Area Process Trenches, further monitoring of iron and manganese is not included in this plan.

The groundwater monitoring activities at the 300 Area Process Trenches under this groundwater monitoring plan sample from a network of four well pairs. Samples are analyzed semiannually for the dangerous wastes *cis*-1,2-DCE and TCE and field parameters (pH, specific conductance, temperature, and turbidity). Water level measurements are collected each time that a sample is obtained from a network well. The network wells are also included in the annual comprehensive March water level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results for the 300 Area Process Trenches are reported on a semiannual basis, per WAC 173-303-645(11)(g), and are summarized in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

2.6 Conceptual Site Model

This section describes the 300 Area Process Trenches CSM for potential contaminant transport to guide future groundwater monitoring. The CSM describes the current understanding of the contaminant release and transport.

Wastewater from the process sewer (containing fuels fabrication and other laboratory waste) was discharged to the 300 Area Process Trenches, two unlined trenches that allowed wastewater to flow directly into the ground. The trenches were in use from 1975 to 1994. The wastewater discharged to the 300 Area Process Trenches contaminated the vadose zone beneath the trenches, as well as the aquifer. The concentrations of waste constituents in the wastewater that was discharged to the 300 Area Process Trenches decreased with time. Administrative controls to prevent hazardous waste from entering the process sewer were put into effect in 1985. After that time, the amount of hazardous waste reaching the trenches was very low, even though the rate of discharge remained above 750 L/min (200 gpm) (see Section 2.3 for waste disposal discussion).

The Hanford formation overlies the Ringold Formation Unit E, with the contact below the water table. The Hanford formation has higher hydraulic conductivity than the Ringold Formation, thereby allowing higher groundwater flow rates. The silt and clay of the Ringold Formation lower mud unit constitute the base of the unconfined aquifer. This lower mud unit also effectively prevents groundwater contamination in the unconfined aquifer from contaminating groundwater below the lower mud unit. Hydraulic head below the mud unit is higher than above the unit, indicating that the general flow would be upward if communication were established between the confined aquifer below and unconfined aquifer above. For example, in 2014 the hydraulic heads in wells 399-1-16C and 399-1-17C, which are screened across the basalt/Ringold lower mud contact, were 8 to 9 m (26 to 30 ft) higher than the hydraulic heads in the wells screened in the shallow unconfined aquifer (399-1-16A and 399-1-17A) and the wells screened in the lower unconfined aquifer (399-1-16B and 399-1-17B).

Fluctuating river stage causes water table fluctuations, which, in turn, affect water table gradient and groundwater flow direction near the 300 Area Process Trenches. Groundwater flow direction beneath the 300 Area Process Trenches is predominantly to the south-southeast when the river stage is low (typical throughout most of the year). During high river stages (typically late spring and early summer), the water table gradient can be reversed, causing bank storage of river water and a temporary groundwater flow direction to the south or southwest. Water level fluctuations as a result of river level fluctuations do not affect *cis*-1,2-DCE because it is detected within the lower portions of the unconfined aquifer.

The 300 Area Process Trenches (316-5 waste site) are remediated and no longer pose an unacceptable risk to human health and the environment in an industrial setting (EPA and DOE, 2013). The results of a CERCLA groundwater risk evaluation found that concentrations of uranium, TCE, and *cis*-1,2-DCE present in groundwater at the 300 Area Industrial Complex provide a basis for remedial action (EPA and DOE, 2013). The only dangerous waste that continues to be detected above the concentration limit in a 300 Area Process Trenches groundwater monitoring well is *cis*-1,2-DCE. At well 399-1-16B, *cis*-1,2-DCE remains in the lower portion of the unconfined aquifer downgradient of the trenches and has been detected consistently in excess of the concentration limit (16 µg/L) (Figure 2-10). Variability in *cis*-1,2-DCE concentrations was observed from 2004 to 2007, after which time concentrations stabilized. No source for the variability has been identified. TCE concentrations have been below the cleanup level (4 µg/L) in the 300 Area Process Trenches monitoring wells since 1999 (Figure 2-11 and Appendix D).

The origin for *cis*-1,2-DCE is attributed to degradation of TCE and PCE historically disposed to nearby liquid waste sites (DOE/RL-2010-99, Appendix F). Large quantities of degreasing solutions were likely disposed to the nearby North Process Pond and South Process Pond (Figure 2-1) during the 1950s and 1960s (PNNL-17666). As reported in PNNL-17666, the infiltration of these discharges through the vadose zone was probably sufficient to cause widespread contamination of the underlying aquifer. Numerical modeling results indicate that it does not appear likely that the source of the *cis*-1,2-DCE observed in well 399-1-16B is the 300 Area Process Trenches (DOE/RL-2010-99, Appendix F).

Natural attenuation through biodegradation is evident in historical monitoring results from well 399-1-16B, where TCE has degraded to *cis*-1,2-DCE. Over the past 20 years, TCE concentrations from this well have decreased to below the cleanup level, *cis*-1,2-DCE concentrations have remained fairly stable, and vinyl chloride has remained below detection limits (Figures 2-10 and 2-11). These concentration data are consistent with conditions appropriate for anaerobic dechlorination of TCE to *cis*-1,2-DCE, but without further significant anaerobic dechlorination to vinyl chloride. Although *cis*-1,2-DCE can degrade anaerobically to vinyl chloride if appropriate microorganisms are present, *cis*-1,2-DCE can accumulate as an end product of TCE dechlorination with little or no vinyl chloride produced when these microorganisms are not present or inhibited. *Cis*-1,2-DCE can also degrade directly to carbon dioxide under aerobic conditions. The absence of *cis*-1,2-DCE and vinyl chloride in downgradient wells indicates that these contaminants are being diluted and degrading aerobically as they slowly diffuse into the higher flow, more aerobic zones of the aquifer. The limited areal and vertical extent of volatile organic compounds (VOCs) in groundwater shows that these natural attenuation processes are preventing significant migration of VOCs (DOE/RL-2010-99, Sections 4.8.4, 5.6, and 5.9; PNNL-17666, Sections 1.2 and 3.3).

2.7 Corrective Action and Groundwater Monitoring Requirements

The groundwater monitoring program at the 300 Area Process Trenches is conducted in accordance with the objectives identified in WAC 173-303-645, as required by the Hanford Facility RCRA Permit, Part II, Condition II.F. Corrective action groundwater monitoring is implemented in accordance with WAC 173-303-645(11), which requires the establishment and implementation of a groundwater monitoring program capable of demonstrating the effectiveness of the corrective action. This requirement states two general objectives:

The corrective action groundwater monitoring program may be based on the requirements for a compliance monitoring program under WAC 173-303-645(10) and must be as effective as that program in determining compliance with the groundwater protection standard under WAC 173-303-645(3).

Monitoring during corrective actions must be capable of determining the success of the corrective action program.

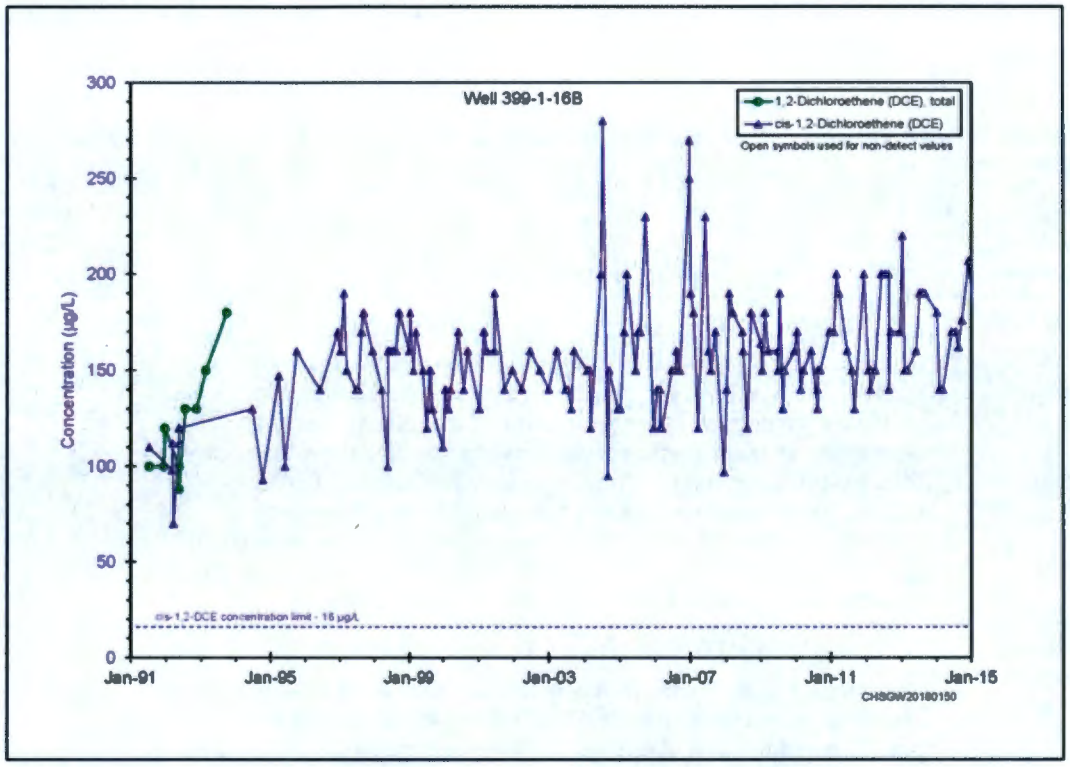


Figure 2-10. *cis*-1,2-Dichloroethene in Groundwater at Well 399-1-16B

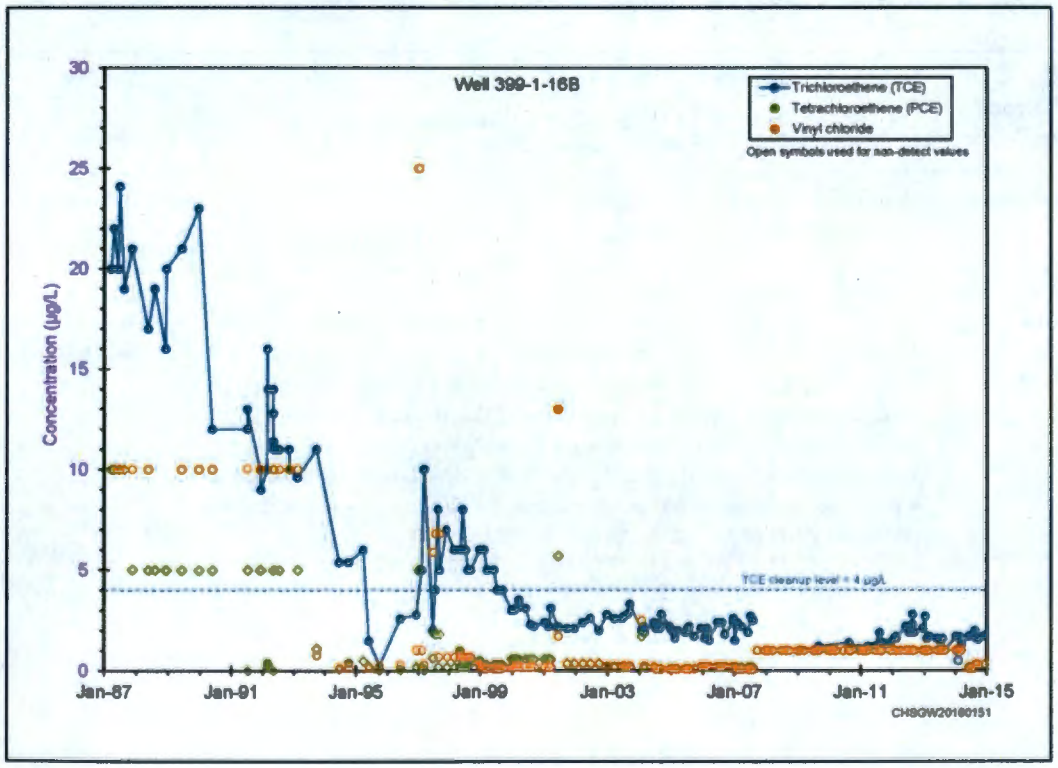


Figure 2-11. Trichloroethene, Tetrachloroethene, and Vinyl Chloride in Groundwater at Well 399-1-16B

Table 2-5 identifies where each groundwater monitoring element of the pertinent applicable regulation is addressed within this plan.

Table 2-5. Pertinent WAC 173-303-645(11) Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
Groundwater Monitoring Program	WAC 173-303-645(11) "Corrective Action Program": (d) In conjunction with a corrective action program, the owner or operator must establish and implement a groundwater monitoring program to demonstrate the effectiveness of the corrective action program. Such a monitoring program may be based on the requirements for a compliance monitoring program under subsection (10) of this section, and must be as effective as that program in determining compliance with the groundwater protection standard under subsection (3) of this section, and in determining the success of a corrective action program under (e) of this subsection, where appropriate.	Section 3.1 Section 3.2 Section 3.3 Section 3.4 Section 3.5 Section 3.7 Section 4.1 Section 4.2
Groundwater Protection Standard	WAC 173-303-645(3) "Groundwater Protection Standard": Conditions specified in the facility permit are designed to ensure that dangerous constituents under WAC 173-303-645(4), detected in the groundwater from a regulated unit do not exceed the concentration limits under WAC 173-303-645(5), in the uppermost aquifer underlying the waste management area beyond the point of compliance under WAC 173-303-645(6), during the compliance period under WAC 173-303-645(7).	Section 3.2
Dangerous Constituents	WAC 173-303-645(4) "Dangerous Constituents": (a) The facility permit will specify the dangerous constituents to which the groundwater protection standard of WAC 173-303-645(3) applies.	Section 3.1
Concentration Limits	WAC 173-303-645(5) "Concentration Limits": (a) The facility permit will specify concentration limits in the groundwater for the dangerous constituents established under WAC 173-303-645(4) of this section.	Section 3.2
Point of Compliance	WAC 173-303-645(6) "Point of Compliance": The facility permit will specify the point of compliance at which the groundwater protection standard WAC 173-303-645(3) applies and at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.	Section 3.3

Table 2-5. Pertinent WAC 173-303-645(11) Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
Compliance Period	WAC 173-303-645(7) "Compliance Period": (a) The facility permit will specify the compliance period during which the groundwater protection standard of WAC 173-303-645(3) applies. The compliance period is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period). (c) If the owner or operator is engaged in a corrective action program at the end of the compliance period specified in (a), the compliance period is extended until the owner or operator can demonstrate that the groundwater protection standard of WAC 173-303-645(3) has not been exceeded for a period of three consecutive years.	Section 3.4 Section 4.2 Appendix D
Number and Location of Wells	WAC 173-303-645(8) "General Groundwater Monitoring Requirements:" (a) The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that: (i) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit. (ii) Represent the quality of groundwater passing the point of compliance. (iii) Allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer.	Section 3.5
Well Configuration	WAC 173-303-645(8) "General Groundwater Monitoring Requirements:" (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must allow collection of representative groundwater samples. Wells must be constructed in such a manner as to prevent contamination of the samples, the sampled strata, and between aquifers and water bearing strata. Wells must meet the requirements applicable to resource protection wells, which are set forth in WAC 173-160, "Minimum standards for construction and maintenance of wells."	Section 3.5 Appendix C
Frequency of Sampling Water Level Measurements	WAC 173-303-645(8) "General Groundwater Monitoring Requirements:" (f) The groundwater monitoring program must include a determination of the groundwater surface elevation each time groundwater is sampled. (g) The owner or operator will determine an appropriate sampling procedure and interval for each hazardous constituent listed in the facility permit.	Section 3.1 Appendix B, Section B2.2

Table 2-5. Pertinent WAC 173-303-645(11) Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement is Addressed in Monitoring Plan
Procedures and Techniques	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (d) The groundwater monitoring program must include at a minimum, procedures and techniques for: (i) Decontamination of drilling and sampling equipment; (ii) Sample collection; (iii) Sample preservation and shipment; (iv) Analytical procedures and quality assurance; and (v) Chain of custody control. (e) The groundwater monitoring program must include consistent sampling and analytical methods that ensure reliable groundwater sampling, accurately measure dangerous constituents and indicator parameters in groundwater samples, and provide a reliable indication of groundwater quality below the waste management area.	Appendix A, Appendix B, Chapter B2 and Sections B5.1, B5.2, and B5.3
Statistical Evaluation Statistical Methods	WAC 173-303-645(8) "General Groundwater Monitoring Requirements:" (h) Groundwater monitoring data will be evaluated using a specified statistical method. The statistical test will be conducted separately for each dangerous constituent in each well. A statistical method not specified in the subsection may be submitted for approval. (i) The statistical method must be appropriate for the distribution of the dangerous constituent. The practical quantification limit used in the statistical method must be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.	Section 4.2 Appendix A, Section A3.1
Recordkeeping and Reporting	WAC 173-303-645(8) "General Groundwater Monitoring Requirements:" (j) Groundwater monitoring data collected in accordance with WAC 173-303-645(8)(g) including actual levels of constituents must be maintained in the facility operating record. The permit specifies when the data must be submitted for review.	Appendix A, Sections A2.6 and A3.9

Note: The references cited in this table are listed in the reference section (Chapter 5) of this plan.

* Part II, Condition II.F of the *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* specifies that a groundwater monitoring program under final status is subject to the requirements of WAC 173-303-645. Because of previous exceedances of the prescribed concentration limits identified in the compliance monitoring plan (WHC-SD-EN-AP-185, Rev. 0), the 300 Area Process Trenches are subject to corrective action monitoring under WAC 173-303-645(11).

WAC = *Washington Administrative Code*

WAC 173-303-645(11) includes requirements for a corrective action program. Implementation of the corrective action plan is included in the 300 Area Process Trenches post-closure plan (DOE/RL-98-31). The post-closure plan (DOE/RL-98-31) specifies that the CERCLA actions for groundwater remediation under the 300-FF-5 ROD (EPA/ROD/R10-96/143) constitute the corrective action measures to be taken in accordance WAC 173-303-645(11). The CERCLA actions are not under the purview of this groundwater monitoring plan. Table 2-6 identifies where elements of corrective action under WAC 173-303-645(11) are discussed within this groundwater monitoring plan and DOE/RL-98-31. Some components of the corrective action requirements also apply to groundwater monitoring requirements and are incorporated within Table 2-5, as appropriate.

Table 2-6. Pertinent WAC 173-303-645(11) Corrective Action Requirements

Corrective Action Element	Pertinent Requirement	Section Where Requirement is Discussed in Monitoring Plan*
Corrective Action Program	WAC 173-303-645(11) "Corrective Action Program" : An owner or operator required to establish a corrective action program under this section must, at a minimum, discharge the responsibilities described in this subsection. (a) Corrective action to ensure that regulated units comply with the groundwater protection standard under WAC 173-303-645(3). The groundwater protection standard will be specified in the facility permit, including: (i) A list of the dangerous constituents and parameters identified under WAC 173-303-645(4); (ii) Concentration limits under WAC 173-303-645(5), for each of those dangerous constituents and parameters; (iii) The compliance point under WAC 173-303-645(6); and (iv) The compliance period under WAC 173-303-645(7).	Section 3.1 Section 3.2 Section 3.3 Section 3.4
Corrective Action	WAC 173-303-645(11) "Corrective Action Program:" (b) The owner or operator must implement a corrective action program that prevents dangerous constituents and parameters from exceeding their respective concentration limits at the compliance point by removing the dangerous waste constituents and parameters or treating them in place. The permit will specify the specific measures that will be taken. (c) The owner or operator must begin corrective action within a reasonable time period after the groundwater protection standard is exceeded. The department will specify that time period in the facility permit. (e) In addition to the other requirements of this section, the owner or operator must conduct a corrective action program to remove or treat in place any dangerous constituents or parameters under subsection (4) of this section, that exceed concentration limits under subsection (5) of this section, in groundwater between the compliance point under subsection (6) of this section, and the downgradient facility property boundary; and beyond the facility boundary, where necessary to protect human health and the environment, unless the owner or operator demonstrates to the satisfaction of the department that, despite the owner's or operator's best	Section 2.2 Section 3.4

Table 2-6. Pertinent WAC 173-303-645(11) Corrective Action Requirements

Corrective Action Element	Pertinent Requirement	Section Where Requirement is Discussed in Monitoring Plan*
	efforts, the owner or operator was unable to obtain the necessary permission to undertake such action. The owner/operator is not relieved of all responsibility to clean up a release that has migrated beyond the facility boundary where off-site access is denied. On-site measures to address such releases will be determined on a case-by-case basis. For a facility seeking or required to have a permit, the corrective action measures to be taken must be specified in the permit. (f) The owner or operator must continue corrective action measures during the compliance period to the extent necessary to ensure that the groundwater protection standard is not exceeded. If the owner or operator is conducting corrective action at the end of the compliance period, he must continue that corrective action for as long as necessary to achieve compliance with the groundwater protection standard. The owner or operator may terminate corrective action measures taken beyond the period equal to the active life of the waste management area (including the closure period) if he can demonstrate, based on data from the groundwater monitoring program under (d) of this subsection, that the groundwater protection standard of subsection (3) of this section, has not been exceeded for a period of three consecutive years.	
Recordkeeping and Reporting	WAC 173-303-645(11) "Corrective Action Program:" (g) The owner or operator must report in writing to the department on the effectiveness of the corrective action program. The owner or operator must submit these reports semiannually. (h) If the owner or operator determines that the corrective action program no longer satisfies the requirements of this section, he must, within forty-five days, submit an application for a permit modification to make any appropriate changes to the program.	Section 4.4

Note: The references cited in this table are listed in the reference section (Chapter 5) of this plan.

WAC = *Washington Administrative Code*

3 Groundwater Monitoring Program

This chapter describes the corrective action groundwater monitoring program for the 300 Area Process Trenches consisting of dangerous waste constituent, concentration limit, point of compliance, compliance period, a monitoring well network, and sampling and analysis protocols. The monitoring program presented herein has been revised from that presented in the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A), and supersedes the monitoring program of the previous plan.

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, constituents analyzed as required for corrective action monitoring, and sampling frequency for monitoring of the 300 Area Process Trenches. The dangerous waste constituents *cis*-1,2-DCE and TCE will be sampled and analyzed semiannually with collection scheduled during low river stage (typically September to November) and high river stage (typically May through June). TCE concentrations have been less than the concentration limit since 1999. Based on recent evaluation of cis-1,2-DCE in well 399-1-16B (ECF-300FF5-15-0017), the groundwater concentration will not reach the concentration level by 2050. Therefore, semiannual sampling, consisting of a single sample per sampling event, is sufficient to monitor the dangerous wastes. Field parameters (pH, conductivity, turbidity, and temperature) will also be sampled semiannually. Water level measurements at each monitoring well will be determined each time a sample is obtained (WAC 173-303-645(8)(f)).

Maintenance problems and sampling logistics resulting from multiple factors including environmental (i.e., inclement weather) and access restrictions (i.e., heightened fire danger, area access restriction due to work by other Hanford contractors such as in the tank farms) sometimes delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well will be sampled. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sampling Management and Reporting group, along with the project scientist, will consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the pre-sampling walkdown that one or more network wells cannot be sampled, then sampling of the well network will not begin and management will be notified. Depending on the situation, the network sampling will be rescheduled within a short time frame (such as 3 to 4 weeks). In some cases, it may not be obvious that sampling cannot be performed until a well is accessed (e.g., an issue with a pump).

Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE-RL and Ecology may agree to resampling wells. DOE-RL will provide informal notification to Ecology if sampling of the network is expected to be delayed for longer than 4 weeks. Ecology may provide input in a timely fashion to DOE-RL on how to proceed. Missed or cancelled sampling events are reported to DOE-RL and are documented in the semiannual monitoring reports required by WAC 173-303-645(11)(g), and the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

Table 3-1. Monitoring Well Network for the 300 Area Process Trenches

Well Name	Purpose	WAC Compliant	Dangerous Waste Constituents and Field Parameters*						
				Dangerous Waste Constituents		Field Parameters			
			Water Level	*cis*-1,2-DCE	Trichloroethene	pH	Specific Conductance	Temperature	Turbidity
399-1-10A	Downgradient	Y	S	S	S	S	S	S	S
399-1-10B	Downgradient	Y	S	S	S	S	S	S	S
399-1-16A	Downgradient	Y	S	S	S	S	S	S	S
399-1-16B	Downgradient	Y	S	S	S	S	S	S	S
399-1-17A	Downgradient	Y	S	S	S	S	S	S	S
399-1-17B	Downgradient	Y	S	S	S	S	S	S	S
399-1-18A	Upgradient	Y	S	S	S	S	S	S	S
399-1-18B	Upgradient	Y	S	S	S	S	S	S	S

* Monitoring as required under WAC 173-303-645(11), "Dangerous Waste Regulations," "Releases from Regulated Units," "Corrective Action Program."

cis-1,2-DCE = *cis*-1,2-dichloroethene

S = to be sampled semiannually

WAC = *Washington Administrative Code*

Y = well is constructed as a resource protection well (WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells")

3.2 Concentration Limit

A dangerous waste constituent from a regulated waste unit may not exceed the concentration limit established by the Hanford Facility RCRA Permit (WAC 173-303-645(5)). The concentration limits for *cis*-1,2-DCE and TCE in the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) were 70 and 5 µg/L, respectively, based on 40 CFR 141.61(a), "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Organic Contaminants." The concentration limits were applied during compliance monitoring to determine whether corrective action was necessary, as required by WAC 173-303-645(10).

Concentration limits of dangerous waste constituents during corrective action are required in WAC 173-303-645(11). The concentration limits for *cis*-1,2-DCE and TCE at the 300 Area Process Trenches in this plan are updated to 16 and 4 µg/L, respectively, which are the cleanup levels identified in the 300 Area ROD/ROD Amendment (EPA and DOE 2013). The concentration limits are based on WAC 173-340-720(4), "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," "Method B Cleanup Levels for Potable Groundwater," cleanup levels.

Because of the previous exceedances of the concentration limit for *cis*-1,2-DCE and TCE and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remediation period do not require additional action. Estimated timeframes for cleanup level attainment for *cis*-1,2-DCE and TCE are not provided in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013). However, an evaluation of cis-1,2-DCE in well 399-1-16B (the only well at which the concentration limit is exceeded) estimated that cis-1,2-DCE will not be less than 16 µg/L by year 2050 (ECF-300FF5-15-0017, Table 7.1). As part of the CERCLA remedial action, evaluation of cis-1,2-DCE and TCE concentrations in wells identified in DOE/RL-2014-42 will be prepared to support the Hanford Site CERCLA 5-year reviews (DOE/RL-2014-42, Section 3.5.1.2). The effectiveness of the MNA remedy will be assessed as part of the CERCLA 5-year review process.

3.3 Point of Compliance

The point of compliance is defined in WAC 173-303-645(6) as a "...vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." This is the location in the uppermost aquifer where groundwater monitoring takes place and the groundwater protection standard applies. As identified in the previous plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A), the point of compliance for the 300 Area Process Trenches is the downgradient monitoring wells. The downgradient monitoring wells are 399-1-10A, 399-1-10B, 399-1-16A, 399-1-16B, 399-1-17A, and 399-1-17B.

The point of compliance wells will be monitored to assess the progress of the corrective action (CERCLA remedial action). Concentrations of *cis*-1,2-DCE and TCE in these wells will be evaluated relative to the concentration limits, in accordance with Section 3.4.

3.4 Compliance Period

The compliance period is defined in WAC 173-303-645(7)(a) as the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period). The 300 Area Process Trenches began operation in 1973 and were closed in 1998, which is a total of 24 years. Therefore, the compliance period for the 300 Area Process Trenches is equal to 24 years and will end in year 2022.

Under WAC 173-303-645(7)(c), if a corrective action program is ongoing at the end of the compliance period (year 2022), then the corrective action must continue for as long as necessary to achieve compliance with the concentration limit. The compliance period is extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.

Based on the CERCLA evaluation of *cis*-1,2-DCE results from well 399-1-16B (ECF-300FF5-15-0017, Table 7.1), the concentration is not estimated to be less than the concentration limit of 16 µg/L by year 2050. Therefore, the compliance period for the 300 Area Process Trenches will be extended past year 2022 until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.

For TCE, monitoring will continue through the compliance period (year 2022). If the TCE concentration is less than the concentration limit for the three year period before the end of the compliance period (years 2019 through 2022), then TCE monitoring will be discontinued at the end of the compliance period. If concentrations are not less than the concentration limit in year 2022 (or have not been less than the concentration limit for three consecutive years), then monitoring will continue until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.

Evaluation methodology for the sampling results is detailed in Section 4.2. Dangerous waste concentrations will be determined with either a 95 percent upper confidence limit (UCL) calculation (for data sets containing detections above the concentration limit) or by visual observation (or data sets containing non-detects and/or detections below the concentration limit). Based on current evaluations of TCE and *cis*-1,2-DCE at well 399-1-16B, it is assumed that TCE concentrations will be less than the concentration limit, and thereby require no further monitoring, before concentrations of *cis*-1,2-DCE will be less than the concentration limit. When it is demonstrated that the concentrations of *cis*-1,2-DCE have not exceeded the concentration limit for three consecutive years, then corrective action monitoring will be discontinued, and the site will be removed from the Hanford Facility RCRA Permit.

3.5 Monitoring Well Network

The current 300 Area Process Trenches monitoring network, which was identified in the previous monitoring plan, consists of two upgradient and six downgradient wells. Figure 2-1 shows the groundwater monitoring network and Table 3-2 summarizes information on the wells.

The four well pairs from the previous monitoring plan are retained in this updated plan. The well pairs monitor the upper portion ("A" wells) and the lower portion ("B" wells) of the unconfined aquifer. Three well pairs are downgradient (399-1-10A, 399-1-10B, 399-1-16A, 399-1-16B, 399-1-17A, and 399-1-17B) and one pair is upgradient (399-1-18A and 399-1-18B). Of the downgradient wells, only 399-1-16B currently exceeds the concentration limit for *cis*-1,2-DCE (Figure 2-10 and Appendix D).

Table 3-2. Attributes for Wells in the 300 Area Process Trenches Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Screen Top (m [ft] bgs)	Screen Bottom (m [ft] bgs)	Water Depth (below Top of Casing) (m [ft])	Water Depth Corrected for Length of Casing above Ground Surface (m [ft] bgs)	Remaining Water Column in Screened Interval (m [ft])	Water Table Measurement Date
399-1-10A	1986	594346.53	116733.99	7.5 (24.5)	12.0 (39.5)	9.4 (30.7)	8.8 (29.0)	3.2 (10.5)	03/19/2015
399-1-10B	1991	594350.85	116728.79	31.9 (104.5)	34.9 (114.5)	10.0 (32.7)	9.0 (29.6)	25.9 (84.9)	03/19/2015
399-1-16A	1986	594318.11	116414.16	9.9 (32.5)	14.5 (47.5)	11.9 (38.9)	11.5 (37.6)	3.0 (9.9)	03/19/2015
399-1-16B	1987	594324.69	116411.62	32.0 (105.0)	35.1 (115.0)	11.7 (38.4)	11.4 (37.3)	23.7 (77.7)	03/19/2015
399-1-17A	1986	594112.87	116413.79	7.6 (25.0)	12.2 (40.0)	10.6 (34.6)	9.9 (32.3)	2.3 (7.7)	03/19/2015
399-1-17B	1986	594104.82	116417.72	30.5 (100.0)	33.5 (110.0)	10.6 (34.9)	9.9 (32.6)	23.6 (77.5)	03/19/2015
399-1-18A[b]	1986	593870.64	117301.57	11.9 (39.0)	16.5 (54.0)	14.3 (46.9)	13.4 (43.8)	3.1 (10.2)	03/19/2015
399-1-18B[b]	1987	593866.06	117297.23	33.1 (108.5)	36.1 (118.5)	14.0 (45.8)	13.1 (43.1)	23.0 (75.4)	03/19/2015

a. Coordinates are in NAD83, *North American Datum of 1983*.

b. Well is upgradient.

bgs = below ground surface

The three downgradient well pairs (399-l-10A, 399-1-10B, 399-l-16A, 399-1-16B, and 399-l-17A, 399-1-17B) are east, southeast, and south, respectively, of the 300 Area Process Trenches to intercept any groundwater contaminants emanating from the site and flowing with the groundwater in directions consistent with historical data. The upgradient well pair (399-l-18A and 399-1-18B) was chosen because it was close to the 300 Area Process Trenches but not too close to the trenches to encounter contaminants temporarily flowing in a reverse direction during elevated river stage. The network in the previous plan was identified to fulfill the requirements of a compliance monitoring program with downgradient and upgradient wells and throughout the unconfined aquifer. The network is retained in this updated plan to ensure adequate monitoring of groundwater affected by the 300 Area Process Trenches dangerous waste constituents and to provide upgradient concentrations for comparison, as needed. These eight wells are constructed to WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," standards.

If a well is within approximately 2 years of going dry, a replacement well will be proposed; such wells are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement Milestone (Ecology et al., 1989) M-24-00. At the 300 Area Process Trenches, the water table is not declining and is directly affected by the Columbia River. Dry well conditions are unlikely.

Construction details and pertinent information for the wells are provided in Appendix C.

3.6 Differences between This Plan and Previous Plan

Table 3-3 identifies the main differences between this plan and the previous groundwater monitoring plan.

Table 3-3. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Constituents	Dangerous waste constituents of concern: • TCE • *cis*-1,2-DCE Other constituent: • Uranium Geochemical evaluation: • Iron • Manganese Two-year monitoring requirement: • Thallium • PCBs • Chrysene • Benzo(a)pyrene Field parameters: • pH • Conductivity • Turbidity • Temperature	Dangerous Wastes: • *cis*-1,2-DCE • TCE Field parameters: • pH • Conductivity • Turbidity • Temperature	The following constituents are not included the current monitoring plan: 1. Uranium – conducted under CERCLA. 2. Iron and manganese – elevated concentrations are due to naturally occurring reducing conditions 3. PCBs, chrysene, benzo(a)pyrene – not detected during the monitoring period 4. Thallium – determined to be naturally occurring

Table 3-3. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Concentration Limit	Based on maximum contaminant levels: *cis*-1,2-DCE: 70 µg/L TCE: 5 µg/L	Based on cleanup levels in 300 Area ROD/ROD Amendment (EPA and DOE, 2013) *cis*-1,2-DCE: 16 µg/L TCE: 4 µg/L	Updated to cleanup levels in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013)
Point of Compliance	Downgradient wells	Same	No change
Sampling Frequency	Semiannual with 4 independent samples (8 samples per year)	Semiannual (2 samples per year)	Concentrations of *cis*-1,2-DCE and TCE have decreased over time and are expected to further attenuate
Well Network	4 well pairs screened at the top and bottom of unconfined aquifer. Downgradient: • 399-1-10A, -10B • 399-1-16A, -16B • 399-1-17A, -17B Upgradient: • 399-1-18A, -18B	Same	No change
Groundwater Flow Direction	East or southeast during low river stage and south or southwest during high river stage	Same	No change
Type of Groundwater Monitoring Program	Compliance, corrective action[b]	Corrective Action	No change
Compliance Period	As defined in WAC 173-303-645(7): Number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period). If corrective action is engaged at the end of the compliance period, then the compliance period is extended until it can be demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.	Based on computation per WAC 173-303-645(7), the compliance period for 300 Area Process Trenches is 24 years and will end in 2022 (Section 3.4). Monitoring for both dangerous wastes will be performed through the compliance period. At the end of the compliance period, if concentrations of TCE in the point of compliance wells are less than the concentration limit (and have been for the final three consecutive years (2019 to 2022), then TCE monitoring will be discontinued.	Identifies the end of the compliance period and requirement to demonstrate that further monitoring is not required.

Table 3-3. Main Differences between this Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
		If corrective action is ongoing at the end of the compliance period (year 2022), then the compliance period will be extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years. The concentration of *cis*-1,2-DCE is not expected to reach the concentration limit by 2022. Therefore, the compliance period will be extended until it can be demonstrated that the concentration limit has not been exceeded for a period of three consecutive years, after which corrective action monitoring will be discontinued. When the compliance period is complete, 300 Area Process Trenches will be removed from the Hanford Facility RCRA Permit.	
Statistical Evaluation	Tolerance interval (under the compliance monitoring plan)	95 percent UCL on the mean, targeting 8 to 10 samples. Calculation of the 95 percent UCL is not performed for data sets that are less than the concentration limit. Also, the practical quantitation limit must be less than the concentration limit	Evaluation methods will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved. See Section 4.2 for details.

Reference: EPA and DOE, 2013, *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1.*

a. WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A), *Groundwater Monitoring Plan for the 300 Area Process Trenches.*

b. The previous monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) was written as a final status compliance monitoring plan. After the requirements for the 300 Area Process Trenches changed to corrective action monitoring, the plan was determined to be acceptable for corrective action monitoring by the Washington State Department of Ecology (Ecology, 1998, "Acceptance of Certification of the 300 Area Process Trenches Clean Closure of the Soil Column and Ground Water Corrective Action Requirements").

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
cis-1,2-DCE = *cis*-1,2-dichloroethene
PCB = polychlorinated biphenyl
RCRA = *Resource Conservation and Recovery Act of 1976*
ROD = record of decision
TCE = trichloroethene
UCL = upper confidence level
WAC = *Washington Administrative Code*

The previous monitoring plan (WHC-SD-EN-AP-185, Rev. 0 and Rev. 0A) monitored uranium, TCE, and *cis*-1,2-DCE as dangerous waste constituents of concern. Iron and manganese were included for a follow-up geochemical evaluation. Thallium, PCBs, chrysene, and benzo(a)pyrene were monitored for a two-year period. Field parameters (pH, conductivity, turbidity, and temperature) were also included.

The 300 Area ROD/ROD Amendment (EPA and DOE, 2013) identified *cis*-1,2-DCE and TCE as contaminants of concern in groundwater because concentrations exceeded drinking water standards. The remedy for both contaminants is MNA. Cleanup levels for *cis*-1,2-DCE (16 µg/ L) and TCE (4 µg/ L) are provided in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) for the 300-FF-5 OU. Concentrations of TCE in the 300 Area Process Trenches monitoring network have not exceeded the cleanup level for TCE since 1999. A 2015 evaluation under CERCLA found that TCE had attained the cleanup level identified in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) at each well in the 300 Area network, except for 399-4-14 (ECF-300FF5-15-0017). Based on these results, EPA approved that monitoring for TCE under CERCLA is required at well 399-4-14 only. This well does not monitor 300 Area Process Trenches (DOE/RL-2015-42).

This revised plan monitors only *cis*-1,2-DCE, TCE, and field parameters. Monitoring of uranium is conducted under the CERCLA remedial action and is not included in this monitoring plan. PCBs, benzo(a)pyrene, and chrysene were not detected the 300 Area Process Trenches groundwater monitoring network during the required two years of monitoring and do not require further monitoring. Thallium was detected during the required two years of monitoring. However, thallium was determined to be naturally occurring based on the evaluation in DOE/RL-2010-99. Based on data analysis and modeling results in ECF-300FF5-14-0044, elevated concentrations of iron and manganese in the deep unconfined aquifer are attributed to naturally occurring reducing conditions. Iron and manganese are not included in this plan.

The concentration limits for *cis*-1,2-DCE and TCE in WHC-SD-EN-AP-185 (Rev. 0 and Rev. 0A) of 70 and 5 µg/L, respectively, was based on 40 CFR 141.61(a). The concentration limits for *cis*-1,2-DCE and TCE in this monitoring plan are updated to the cleanup levels of 16 and 4 µg/L, respectively (EPA and DOE, 2013). Because of the previous exceedances of the concentration limit for *cis*-1,2-DCE and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remediation period do not require additional action.

The sampling frequency in the previous monitoring plan met the requirements of compliance monitoring under WAC 173-303-645(10) and included semiannual sampling, with four independent samples collected at each sampling event, for a total of eight samples per year. Since approval of the plan in 1995, the 300 Area Process Trenches have undergone remediation and concentrations of *cis*-1,2-DCE have decreased and further attenuation of *cis*-1,2-DCE is expected. The remedial action (MNA) chosen for *cis*-1,2-DCE and TCE in the 300 Area ROD/ROD Amendment (EPA and DOE, 2013) will monitor groundwater in the 300 Area Industrial Complex until the cleanup level is attained. Based on recent evaluation of *cis*-1,2-DCE in well 399-1-16B (ECF-300FF5-15-0017, Table 7.1), the concentration will not reach the concentration limit by year 2050. Therefore, the more frequent sampling performed under the previous plan is not necessary for corrective action monitoring and semiannual sampling, consisting of a single sample per sampling event, is included in this updated monitoring plan (see Section 4.2 for details).

The previous plan did not define the compliance period specific to the 300 Area Process Trenches. The compliance period is determined in this plan and extends to year 2022 (Section 3.4). However, the concentration of *cis*-1,2-DCE is not expected to reach the concentration limit by year 2022. Therefore, the compliance period will be extended until it can be demonstrated that the concentration limit has not been

exceeded for a period of three consecutive years, after which corrective action monitoring will be discontinued and the site will be removed from the Hanford Facility RCRA Permit.

The previous plan included a tolerance interval method for statistical evaluation of the compliance monitoring data. The current plan is updated with a confidence interval statistical method that will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved. Nonstatistical evaluation of the results will be used for data sets that are below the concentration limit and have a practical quantitation limit less than the concentration limit.

3.7 Sampling and Analysis Protocol

In accordance with the Hanford Facility RCRA Permit, the groundwater protection regulations of WAC 173-303-645 dictate the groundwater sampling and analysis requirements applicable to final status TSD units. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification tasks are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

The objective of the corrective action monitoring program is to monitor the concentration trends to demonstrate the effectiveness of the corrective action. Accordingly, the objective of the statistical evaluation during the corrective action is to monitor the concentration trends of the dangerous wastes to confirm that the corrective action is progressing as expected.

In corrective action monitoring, a UCL of the mean can be compared to a fixed regulatory limit to determine with prescribed confidence whether the mean concentration of the target population (population of interest) significantly exceeds the fixed limit (EPA, 1989, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Interim Final Guidance*; EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*). UCLs of the mean are routinely calculated using ProUCL (EPA, 2013), a software package developed for EPA that has undergone expansions and upgrades, including the most recent in 2013.

The 95 percent UCL of the mean, hereafter referred to as a 95 percent UCL, calculated with ProUCL, Version 5.0.00 (EPA, 2013) is the statistic used to evaluate groundwater data collected under this monitoring plan. Revised versions of ProUCL will be used as they become available. ProUCL calculates an appropriate 95 percent UCL considering data distribution, data set size, skewness of the data, and percentage of nondetects. The ProUCL technical guide recommends data sets include a minimum of eight to ten independent results, with at least four detections within the data set. Replicate samples are not considered independent.

The most recent eight to ten independent monitoring results of each dangerous waste constituent (*cis*-1,2-DCE and TCE) from the 300 Area Process Trenches monitoring wells are the data sets used to compute a 95 percent UCL on an intrawell basis. When available, results from the last nine or ten independent sampling events (whichever is the maximum number of results) from a given well are used for the calculation.

The wells in this plan were previously monitored at a semiannual frequency with four independent samples per event (eight independent samples per year). The sampling frequency is changed to semiannual with a single sample per event (two independent samples per year) in this updated plan. Therefore, the entire last year of results collected at the frequency under the previous plan (eight samples per year) will be included in initial data sets used to calculate the 95 percent UCL, until eight semiannual samples are available. This will provide a sufficient number of sample results for calculation and will retain the full final year of sample results collected under the previous plan as a set, as opposed to including results that represent only a partial year. Once eight semiannual results are available (e.g., four years of sampling under this plan), the results collected under the previous monitoring plan will no longer be included in data sets.

Not all data sets require computation of a 95 percent UCL. When the sample results in the data set comprising eight to ten semiannual samples (or additional samples collected under the previous monitoring plan as described above) are less than the concentration limit, a nonstatistical or visual analysis of the data (such as presented in Appendix D) is appropriate. In these cases, each result in the data set must be less than the concentration limit. In addition, the practical quantitation limit for each sample in the data set must not exceed the concentration limit.

The 95 percent UCL calculations are performed as necessary for the 300 Area Process Trenches point of compliance well results to support preparation of the semiannual reports required by WAC 173-303-645(11)(g). These reports will be used to monitor the concentration trends to demonstrate the effectiveness of the corrective action. Any calculated 95 percent UCL values will be compared to the concentration limits in these reports.

As discussed in Section 3.4, if a corrective action program is ongoing at the end of the compliance period (year 2022), then the corrective action must continue and the compliance period is extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years. However, for TCE it is possible that concentrations will be less than the concentration limit for the three consecutive year period before the end of the compliance period (years 2019 through 2022). In this case, monitoring will be discontinued at the end of the compliance period.

The sample frequency may be adjusted during the final three consecutive year time period to obtain additional sample results (eight to ten) for calculation of a 95 percent UCL. After three years of samples are collected, the data will be evaluated as described above. Calculation of a 95 percent UCL, if required, will be performed using the last eight to ten independent samples collected at a given well. The resulting 95 percent UCL is compared to the concentration limit to determine whether the dangerous waste constituent is below the concentration limit. If the 95 percent UCL is below the concentration limit, then monitoring will be discontinued.

Evaluations of the performance monitoring under the CERCLA remedy (MNA) will be provided in 300-FF-5 OU project reports, as needed (DOE/RL-2014-42) and will be prepared to support the sitewide CERCLA five-year review. Performance monitoring results for the 300-FF-5 OU will be reported at least biennially (DOE/RL-2014-42). The results of CERCLA evaluations for *cis*-1,2-DCE and TCE may be used to supplement the evaluations described above, which are performed to monitor the concentration trends to demonstrate the effectiveness of the corrective action.

4.3 Interpretation

Data are used to interpret groundwater conditions at the 300 Area Process Trenches. Interpretive techniques may include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to the equal potential lines on the maps.
- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.

4.4 Reporting

The effectiveness of the corrective action program is reported twice each year as required by WAC 173-303-645(11)(g). Results from this monitoring plan are reported in both the semiannual corrective action groundwater report and the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

In accordance with WAC 173-303-645(11)(h), if it is determined by DOE that the corrective action program no longer satisfies the requirements of the corrective action program under WAC 173-303-645(11), an application for a permit modification to make any appropriate changes to the program will be submitted within 45 days.

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Appendix A

Quality Assurance Project Plan

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Figure

Figure A-1. Project Organization 2

Terms

DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
DUP	duplicate (laboratory)
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
S&GRP	Soil and Groundwater Remediation Project
SAF	Sampling Authorization Form

SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
Tri-Party Agreement Action Plan	*Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b)
TSD	treatment, storage, and disposal
VOC	volatile organic compound

A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan) require the QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal (TSD) units, as well as for past practice processes. This QAPjP also describes the applicable requirements and controls based on guidance provided in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following five chapters, which describe the quality requirements and controls applicable to the 300 Area Process Trenches groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Assessment and Oversight
- Chapter A5, Data Review and Usability
- Chapter A6, References

A2 Project Management

This chapter addresses the management approaches planned, project goals, and planned output documentation.

A2.1 Project/Task Organization

Project organization (regarding routine groundwater monitoring) is described in the following subsections and illustrated in Figure A-1.

A2.1.1 DOE-RL Manager

Hanford Site cleanup is the responsibility of U.S. Department of Energy (DOE)-Richland Operations Office (RL). The DOE-RL Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976* (RCRA); *Atomic Energy Act of 1954*; and Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

A2.1.2 DOE-RL Project Lead

The DOE-RL Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to the DOE-RL management.

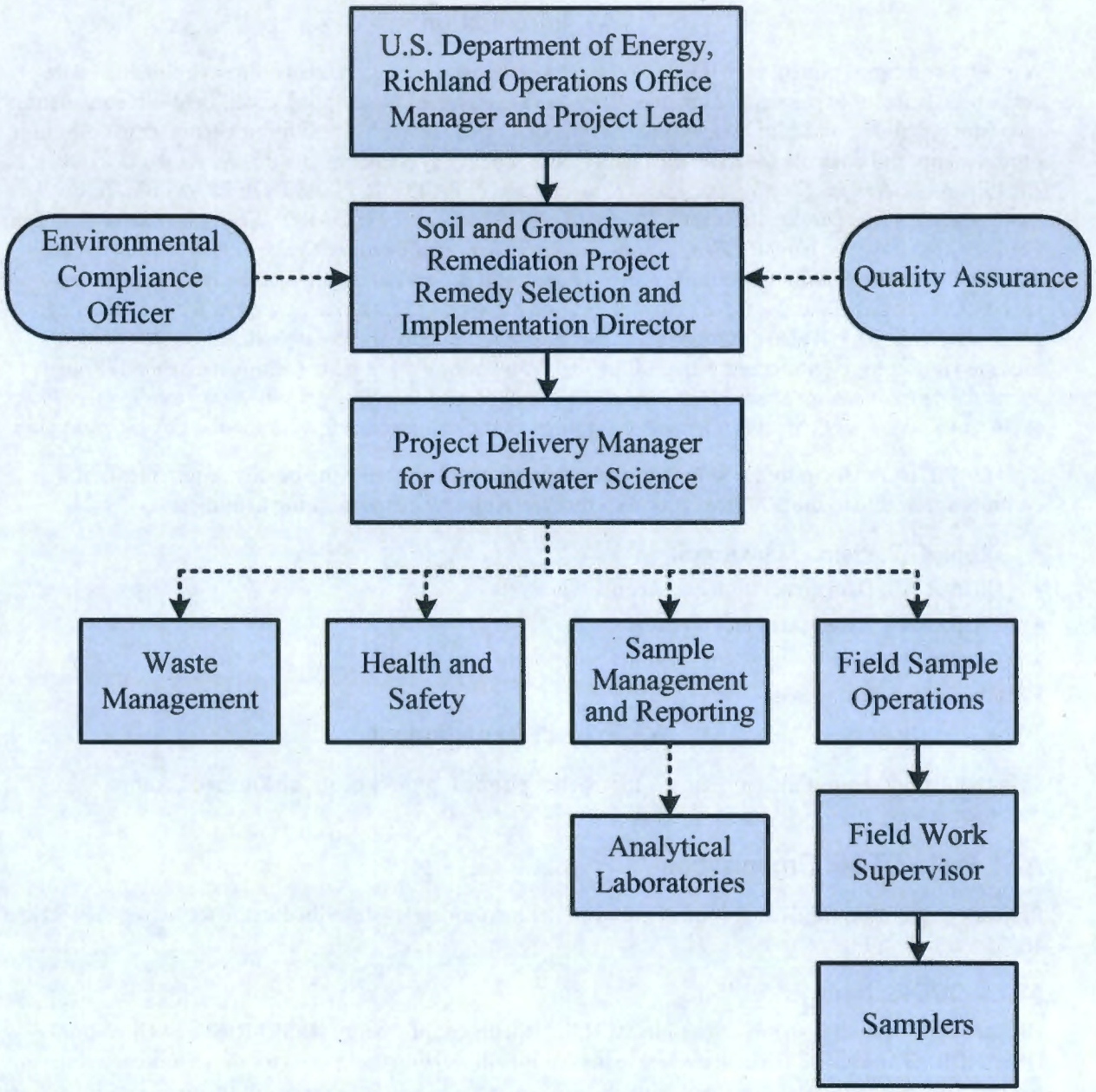

Figure A-1. Project Organization

A2.1.3 Soil and Groundwater Remediation Project Remedy Selection and Implementation Director

The Soil and Groundwater Remediation Project (S&GRP) Remedy Selection and Implementation Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Remedy Selection and Implementation Director also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

A2.1.4 Project Delivery Manager for Groundwater Science

The Project Delivery Manager for Groundwater Science is responsible for direct management of activities performed to meet TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with, and reports to, DOE-RL and primary contractor management regarding TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The Project Delivery Manager for Groundwater Science assigns scientists to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the Sampling Authorization Form (SAF), which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures it is appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. The SMR group is responsible for informing the Project Delivery Manager for Groundwater Science of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

FSO is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect groundwater samples in accordance with this groundwater monitoring plan and corresponding standard procedures and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling documentation. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project and overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents, including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

A2.1.8 Environmental Compliance Officer

The ECO provides technical oversight, direction, and acceptance of project and subcontracted environmental work and develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A2.1.9 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or internal primary contractor work requirements.

A2.1.10 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements, to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A2.1.11 Analytical Laboratories

The analytical laboratories analyze samples, in accordance with established procedures and the requirements of this plan, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Statements of work flow down quality requirements consistent with the HASQARD (DOE/RL-98-68). The laboratories are evaluated under the DOE Consolidated Audit Program and must be accredited by the Washington State Department of Ecology (Ecology) for the analyses performed for S&GRP.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste,* Part II, Condition II.F, which specifies groundwater monitoring under WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," for final status facilities. More specific information on the activities to satisfy these requirements is provided in the main text of this monitoring plan, such as in Chapter 1 and Sections 2.7, 3.1, 3.2, 3.3, 3.4, 3.5, and 4.2. Background information on monitoring is also provided in the main text Sections 2.2, 2.5, and 3.6.

A2.3 Project/Task Description

The focus of this plan is to monitor for dangerous waste in accordance with WAC 173-303-645(11), evaluate the well network, and interpret analytical results. The dangerous wastes and field parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main text (Chapter 3). Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the monitoring plan. In support of this objective, data descriptors known as data quality indicators (DQIs) are used to help determine the acceptability and usefulness of the data to the user. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These DQIs are defined for the purposes of this document in Table A-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section A5.3).

A2.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, "Personnel Training." The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable *Code of Federal Regulations* and *Washington Administrative Code* requirements. Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up-to-date prior to performing any field work.

A2.6 Documents and Records

The Project Delivery Manager for Groundwater Science (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Elements of the monitoring plan that are required by WAC 173-303-645 (e.g., water-level measurements will be collected each time a sample is obtained) cannot be changed.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, and surrogates)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or re-measurement.
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data quality assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, field transfer blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media. • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
			• Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V, as amended.*

a. Acceptance criteria for QC elements are provided in Table A-5.

b. For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QC = quality control

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Temporary addition of wells or other constituents, or increased sampling frequency that does not affect the requirements of WAC 173-303-645.	Project Delivery Manager for Groundwater Science approves temporary change; provides informal notification to DOE-RL.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan that impacts the corrective action monitoring requirements of WAC 173-303-645, including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, and loss of samples in transit.	Project Delivery Manager for Groundwater Science provides electronic notification to DOE-RL. DOE-RL provides informal notification to Ecology as appropriate.	Annual Hanford Site RCRA groundwater monitoring report
Planned change to groundwater monitoring activities that impacts the corrective action monitoring requirements of WAC 173-303-645, including addition or deletion of supporting constituents, change of sampling frequency for supporting constituents, or changes to well network.	Project Delivery Manager for Groundwater Science obtains DOE-RL approval; revise monitoring plan as appropriate.	Revised groundwater monitoring plan and modification to Hanford Facility RCRA Permit
Anticipated unavoidable changes.	Project Delivery Manager for Groundwater Science provides electronic notification to DOE-RL; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report Permanent changes require revised groundwater monitoring plan and modification to Hanford Facility RCRA Permit

References: Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*)

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units"

DOE-RL = U.S. Department of Energy, Richland Operations Office

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

SMR = Sample Management and Reporting

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The FWS, SMR, and any field crew supervisors are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the groundwater monitoring plan. The SMR group will ensure that any deviations from the plan are reflected in revised field sampling documents for the samplers and analytical laboratory. The FWS or appropriate field crew supervisors will ensure that deviations from the plan or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The Project Delivery Manager for Groundwater Science, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The Project Delivery Manager for Groundwater Science is also responsible for ensuring that project files are setup, as appropriate, and/or maintained. The project files will contain project records or references to their storage locations. Project files generally include, as appropriate, the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract

The following records are managed and maintained by SMR personnel:

- Completed field sampling logbooks
- Groundwater sample reports and field sample reports
- Completed chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information
- Training records for employees, as they relate to analytical methods.
- Laboratory state accreditation records
- Laboratory audit records

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein. Records of analyses required by WAC 173-303-645(11), as well as associated groundwater surface elevations required by WAC 173-303-645(8) are to be maintained throughout the active life of a facility and post-closure care period.

The results of corrective action groundwater monitoring are reported twice each year as required by WAC 173-303-645(11). Groundwater monitoring results are also presented in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition to ensure that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

A3.1 Analytical Method Requirements

Analytical method requirements for samples collected are presented in Table A-3. Updated U.S. Environmental Protection Agency (EPA) methods may be substituted for the analytical methods identified in Table A-3.

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L)
Dangerous Waste Constituents		
Volatile Organic Compounds		
cis-1,2-Dichloroethene	EPA 8260	5
Trichloroethene		1
Site-Specific Measurements		
Field Parameters		
pH	Field measurement Instrument/meter	N/A
Specific Conductance		N/A
Temperature		N/A
Turbidity		N/A

Note: Analytical methods and highest allowable PQLs provided in this table do not represent EPA requirements but are intended solely as guidance.

a. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*. Equivalent methods may be substituted.

b. Highest allowable practical quantitation limits are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower. Method detection limits are three to five times lower than quantitation limits.

EPA = U.S. Environmental Protection Agency

N/A = not applicable

PQL = practical quantitation limit

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with HASQARD (DOE/RL-96-68) requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Table A-3 provides the parameters (if any) identified for field measurements. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

QC requirements specified in the plan must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC samples are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in HEIS, as appropriate.

Table A-4. QC Requirements

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field Duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed When needed, the minimum is one for every analytical method, for analyses performed.	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	One in 20 well trips	Cross-contamination from containers or transportation
Field Transfer Blanks	One each day that volatile organic compounds are sampled	Contamination from sampling site
Equipment Blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an EB is not required; otherwise, one for every 20 samples[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical QC[b]		
Laboratory Sample Duplicates	One per analytical batch[c]	Laboratory reproducibility and precision
Matrix Spikes	One per analytical batch[c]	Matrix effect/laboratory accuracy
Matrix Spike Duplicates	One per analytical batch[c]	Laboratory accuracy and precision
Laboratory Control Samples	One per analytical batch[c]	Laboratory accuracy
Method Blanks	One per analytical batch[c]	Laboratory contamination
Surrogates	One per analytical batch[c]	Recovery/yield

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. For portable pumps, equipment blanks are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

b. Batching across projects is allowed for similar matrices (e.g., all Hanford groundwater).

c. Unless not required by, or different frequency is called out in, laboratory analysis methods.

EPA = U.S. Environmental Protection Agency

QC = quality control

Table A-5. Laboratory Quality Control and Acceptance Criteria

Analyte	Quality Control	Acceptance Criteria	Corrective Action
Volatile Organic Compounds			
Volatile organic compounds by gas chromatography/mass spectrometry (*cis*-1,2-dichloroethene and trichloroethene)	MB	<MDL[a] <5% sample concentration	Flagged with "B"
	LCS	70 to 130% Recovery	Review Data[b]
	DUP[c]/MSD[c]	≤20% RPD[d]	Review Data[b]
	MS/MSD	70 to 130% Recovery	Flag with "T"
	SUR	70 to 130% Recovery	Review Data[b]
	EB, FTB, FXR	<2 times MDL[a]	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[d]	Review Data[b]

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Specific conductance, pH, temperature, and turbidity are not listed as they are measured in the field.

a. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is < 5 times the MDL.

b. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect (Y flag), failed field QC (Q flag), or rejected (R flag).

c. Either a DUP or a MSD is to be analyzed to determine measurement precision.

d. Applies when at least one result is greater than the laboratory PQL (chemical analyses).

DUP = laboratory sample duplicate
EB = equipment blank
EPA = U.S. Environmental Protection Agency
FTB = full trip blank
FXR = field transfer blank
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference
SPLIT = field split
SUR = surrogate

Data Flags:

B = possible laboratory contamination: analyte was detected in the associated method blank.
Q = problem with associated field QC blank: results were out of limits.
T = result may be biased: associated matrix spike result was outside the acceptance limits (gas chromatograph/mass spectrometry only).

A3.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure that reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and three types of field blanks (full trip blanks [FTBs], field transfer blanks [FXRs], and equipment blanks [EBs]). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described below:

Field duplicates: independent samples collected as close as possible to the same time and same location as the scheduled sample, and intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field splits (SPLITs): two samples collected as close as possible to the same time and same location and intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

Full trip blanks (FTBs): bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is identical to the set that will be collected in the field. It is filled with high-purity reagent water[1], and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Field transfer blanks (FXRs): preserved volatile organic analysis sample vials filled with high-purity reagent water at the sample collection site where volatile organic compounds (VOCs) are collected. Samples will be prepared during sampling to evaluate potential contamination attributable to field conditions. After collection, FXR sample vials will be sealed and placed into the same storage containers with samples collected the same day for the associated sampling event. FXR samples will be analyzed for VOCs only.

Equipment blanks (EBs): Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with samples from the associated sampling event. EB samples will be analyzed for the same constituents as samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process and these samples are not required for disposable sampling equipment.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), laboratory control samples (LCSs), method blanks (MBs), and surrogates (SURs). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*) and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC checks and their typical frequencies are listed in Table A-4. Acceptance criteria are shown in Table A-5. Descriptions of the various types of laboratory QC samples are as follows:

Laboratory sample duplicate (DUP): an intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

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[1] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

Matrix spike (MS): an aliquot of a sample spiked with a known concentration of target analyte(s). MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate (MSD): a replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Laboratory control sample (LCS): a control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.

Method blank (MB): an analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Surrogate (SUR): a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and measurement systems in a manner similar to the analytes of interest. Because SURs are added to every standard, sample, and QC sample, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Laboratories are required to analyze samples within the holding times specified in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an "H."

Table A-6. Preservation and Holding Time Guidelines for Laboratory Analyses

Constituent/Parameter	Preservation*	Holding Time
Dangerous Waste Constituent		
Volatile organic compounds (*cis*-1,2-dichloroethene and trichloroethene)	Store ≤6°C, adjust pH to <2 with sulfuric acid or hydrochloric acid	14 Days

Notes: The container type for a sample is available on the chain-of-custody.

The information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Specific conductance, pH, temperature, and turbidity are not listed because they are measured in the field.

* For preservation identified as stored at ≤6°C, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

A3.4 Measurement Equipment

Each user of the measuring equipment is responsible to ensure that equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with manufacturer specifications and other approved methods.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or should have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with applicable Hanford Site requirements.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with test methods in SW-846 and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

A3.8 Nondirect Measurements

Data obtained from sources, such as computer databases, programs, literature files, and historical databases, will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

A3.9 Data Management

The SMR group, in coordination with the Project Delivery Manager for Groundwater Science, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods. Records of data analyses and groundwater surface elevations are maintained as required by WAC 173-303-645(8)(j).

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group through an established process. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the Project Delivery Manager for Groundwater Science. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

A4 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this plan, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the Project Delivery Manager for Groundwater Science.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with laboratory QA plans. The SMR group oversees offsite analytical laboratories and verifies that laboratories are qualified to perform Hanford Site analytical work.

A4.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by self-assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues reported by the laboratories are communicated to the SMR group, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the Project Delivery Manager for Groundwater Science.

A5 Data Review and Usability

This chapter addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A5.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met. Furthermore, a review of QC data is used to determine whether analyses have met the data quality requirements specified in this plan.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results also will be reviewed to ensure that they are usable.

The project scientist, assigned by the Project Delivery Manager for Groundwater Science, will perform a data review to help determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in submittal of a request for data review on questionable data. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the request for data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

A5.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science and under the direction of the SMR group. It is based on the results of the QC samples for an individual network, discussions with the project scientist, and discussions with the laboratory services manager. If defined as appropriate, data validation (third party) will be performed at a minimum frequency of 5 percent and be based on EPA functional guidelines.

A5.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data quality needs. For routine groundwater monitoring performed through this groundwater monitoring plan, the DQA is captured in the DQA appendix associated with the annual Hanford Site RCRA groundwater report (e.g., DOE/RL-2016-12), which evaluates field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of the Project Delivery Manager for Groundwater Science and documented in a report overseen by the SMR group.

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Appendix B

Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
gpm	gallons per minute
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
NTU	nephelometric turbidity unit
QA	quality assurance
QC	quality control
SMR	Sample Management and Reporting

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B1 Introduction

Groundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* and implemented in WAC 173-303, "Dangerous Waste Regulations," has been conducted since the mid-1980's. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken; equipment and its use; cleaning and decontamination; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B provide the sampling and analysis essentials necessary for the groundwater monitoring plan: sample collection, sample preservation and holding times, chain-of-custody control, analytical procedures, and field and laboratory quality assurance (QA)/quality control (QC).

This appendix provides more specific elements of the sampling protocols and techniques used for the groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, constituents to be analyzed, and sampling frequency for the groundwater monitoring at the 300 Area Process Trenches.

B2 Sampling Methods

Sampling may include, but is not limited to, the following methods:

- Field screening measurements
- Groundwater sampling
- Water level measurements

Groundwater samples will be collected in accordance with the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (32.3°F)
- **Conductivity** – two consecutive measurements agree within 10 percent of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist's recommendation)

Unless any special requirements are requested from project scientists, wells are typically purged using the equivalent volume as that of three borehole diameters multiplied by the length of the saturated portion of the well screen. Stable field readings are also required as specified above. The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gallons per minute [gpm]), depending on the pump although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged for a minimum of 1 hour and are then sampled once stable field readings are obtained.

Field measurements (except for turbidity) are obtained using of a flow-through cell. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean, stainless-steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, and conductivity. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean, stainless-steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g., metals), both filtered and unfiltered samples are collected. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline, disposable 0.45 μm filter is used.

Typically, three traditional types (i.e., Grundfos[1], Hydrostar[2], and submersible electrical pumps) of environmental grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support pumping of samples because of low yield or the physical characteristics of the well. In these cases, a grab sample may be obtained. In cases where there is not sufficient yield, purgewater activities are not performed.

Low-purge-volume sampling methodology for the collection of groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically on the order of 0.1 to 0.5 L/min (0.26 to 0.13 gpm). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low-purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

For certain types of samples, preservatives are required. Preservatives, based on the analytical methods used, are added to the collection bottles before their use in the field. Samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, sampling associated with this groundwater monitoring plan will be performed in accordance with the requirements of DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), pertaining to sample collection, collection equipment, and sample handling.

Sample preservation and holding-time requirements are specified for groundwater samples in Appendix A, Table A-6. These requirements are in accordance with the analytical method specified in Appendix A, Table A-3. The container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding-time restrictions.

Holding time is the maximum allowable period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater*, and SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition; Final Update V*. Recommended holding times are also provided in HASQARD (DOE/RL-96-68) and in applicable laboratory contracts.

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[1] Grundfos® is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.

[2] Hydrostar® is a registered trademark of KYB Corporation, Tokyo, Japan.

B2.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each specific sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment and pumps is performed using high-purity water[3] in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the equipment is washed in a phosphate-free detergent solution, followed by rinsing with water in three sequential containers. After the third water rinse, equipment that is stainless-steel or glass is rinsed in a 1M nitric acid solution (pH less than 2). Equipment is then rinsed with water in three sequential containers (the water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at 50°C (122°F) for items that are not metal or glass or at 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is enclosed in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. The pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with water. The pump is submerged in water and 30.3 L (8 gal) of water is pumped through the unit and disposed. The pump is removed from the water and the intake and housing are covered with plastic sleeving. The cleaning is documented on a tag that is affixed to the pump, and the tag will include the following information:

- Date pump cleaned
- Pump identification
- Comments
- Signature of person performing decontamination

[3] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater surface elevation at each monitoring well is required by WAC 173-303-645(8)(f), "Dangerous Waste Regulations," "Releases from Regulated Units," "General Groundwater Monitoring Requirements." Using a calibrated depth measurement tape, the depth-to-water is recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.); the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks or data forms are required for field activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor (FWS), cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks or on data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were conducted; reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation (if any) of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook where detailed information is recorded.

- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

B3.1 Corrective Actions and Deviations for Sampling Activities

The Project Delivery Manager for Groundwater Science, FWS, appropriate field crew supervisors, and Sample Management and Reporting (SMR) personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The Project Delivery Manager for Groundwater Science, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Appendix A, Table A-2.

B4 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with the HASQARD requirements (DOE/RL-96-68).

Field instrumentation, calibration, and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturer's recommendations for storage and handling of standards (if any) will be followed.

B5 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and analytical database is used to track samples from the point of collection through the laboratory analysis process.

B5.1 Containers

Samples shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the laboratory lot number of the bottles used in sample collection. When commercially pre-cleaned containers are used in the field, the name of the manufacturer, lot identification, and certification shall be retained for documentation.

Containers shall be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, new and previous custodians will sign the record and note the date and time. The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.

The following minimum information is required on a completed chain-of-custody form:

- Project name
- Collectors' names
- Unique sample number
- Date and time of collection
- Matrix
- Preservatives
- Chain of possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)

- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group; so special direction for analysis can be provided to the laboratory if deemed necessary.

B5.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, **"Transportation," "General Information, Regulations, and Definitions," through** 49 CFR 177, **"Carriage by Public Highway."** [4] Carrier-specific requirements defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations* shall also be used when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2000-56, *Waste Management Plan for the 300-FF-5 Operable Unit.* For waste designation purposes, wells listed in Table 3-1 in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System, and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required.

Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater and decontamination fluids will be collected and managed in accordance with DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*; and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan.* Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements.

Packaging and labeling during waste storage and transportation will meet WAC 173-303 and DOT requirements, as appropriate. Packaging exceptions to DOT requirements may be used for onsite waste shipments if documented as such and if the packaging provides an equivalent degree of safety during transportation.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities.

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[4] Transportation regulations **49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel,"** are not applicable, as these two transportation methods are not used.

B7 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, "Worker Safety and Health Program," which incorporates the standards of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response" 10 CFR 830, "Nuclear Safety Management"; and 10 CFR 835, "Occupational Radiation Protection." The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control; and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

B8 References

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=47e3de0454360a17406cb89ade0c966d&mc=true&node=pt10.4.830&rgn=div5.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=57ef404ac6f4734a67fd97302b2d7f7f&node=pt10.4.835&rgn=div5.

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49 CFR 171, "General Information, Regulations, and Definitions."

49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans."

49 CFR 173, "Shippers-General Requirements for Shipments and Packagings."

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49 CFR 177, "Carriage by Public Highway."

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Appendix C

Well Construction

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C1 Introduction

This appendix provides the following information for the 300 Area Process Trenches groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be monitored (the portion of the aquifer that is located at the well screen or perforated casing) (Table C-1)
- The following sampling interval information, as shown in Table C-2:
  - Elevation at top of the screen or perforated interval
  - Elevation at the bottom of the screen or perforated interval
  - Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)

Figures C-1 through C-8 provide the well construction and completion summary for 399-1-10A, 399-1-10B, 399-1-16A, 399-1-16B, 399-1-17A, 399-1-17B, 399-1-18A, and 399-1-18B.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
LU	**Lower Unconfined.** Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse hydrogeologic unit or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
TU	**Top of Unconfined.** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-2. Sampling Interval Information for Wells within the 300 Area Process Trenches Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])
399-1-10A	TU	106.9 (350.5)	102.3 (335.5)	4.6 (15.0)
399-1-10B	LU	82.7 (271.0)	79.6 (261.0)	3.1 (10.0)
399-1-16A	TU	107.0 (350.8)	102.4 (335.8)	4.6 (15.0)
399-1-16B	LU	84.8 (278.1)	81.8 (268.1)	3.1* (10.0)
399-1-17A	TU	107.8 (353.2)	103.2 (338.2)	4.6 (15.0)
399-1-17B	LU	85.0 (278.6)	81.9 (268.6)	3.1 (10.0)
399-1-18A	TU	107.3 (351.9)	102.7 (336.9)	4.6 (15.0)
399-1-18B	LU	85.9 (281.8)	82.9 (271.8)	3.1* (10.0)

Reference: NAVD88, *North American Vertical Datum of 1988*.

Note: See Table 3-2 in main text for depth of remaining water column.

* The open interval length is 3.1 m (10.0 ft) in length. Construction records for the well are reported in standard units (feet), which are converted to meters for this table. Due to rounding of the metric unit, the computed open interval length based on the top and bottom elevation differs slightly from the actual open interval length.

TU = Top of Unconfined, as described in Table C-1

LU = Bottom of Unconfined, as described in Table C-1

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 13Nov86

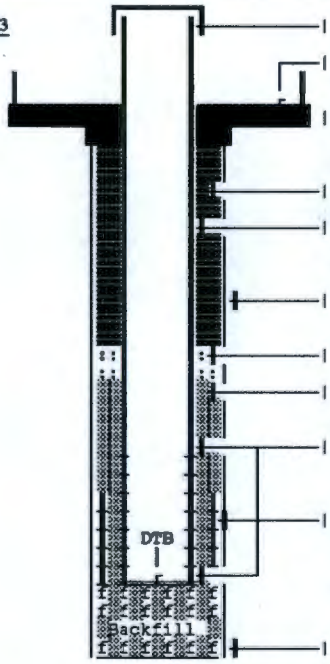
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 22Nov86

WELL NUMBER: 399-1-10A
TEMPORARY WELL NO: S-3
Hanford Coordinates: N/S S 22,293 E/W E 14,413
State RN 57,083.8 RE 16,018.6
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 371.94-ft Brass cap

Depth to water: 29.0-ft Nov86
(Ground surface) 29.4-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-10: Coarse to medium SAND
10-20: Sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, sandy PEBBLES



Elevation of reference point: [373.65-ft] (top of casing)
Height of reference point above ground surface [1.71-ft]
Depth of surface seal [0-13.5-ft]
Type of surface seal: Portland cement 4-ft x 4-ft x 6-in(nom) extending 3-ft into annulus.
Bentonite crumbles to 13.5-ft
6-in ID stainless steel casing, +1.7-24.5-ft
Hole diameter, 0-45.0-ft, 11-in nominal
Volclay bentonite pellets, 13.5-18.5-ft
Silica sand pack, 18.5--39.5-ft, 8-12-mesh
6-in stainless steel screen 24.5-39.5-ft, #40-slot
10-in telescoping screen, 29.5-39.5-ft
DTB=Depth to bottom, 39.1-ft, 12Feb92
Borehole drilled depth: [45.0-ft]

Drawing By: RKL/3-01-10A.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

Figure C-1. Well 399-1-10A Construction and Completion Summary

A8064

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Raw water
Driller's Name: D Rossman
Drilling Company: Kaiser Engineers
Date Started: 06Sep91

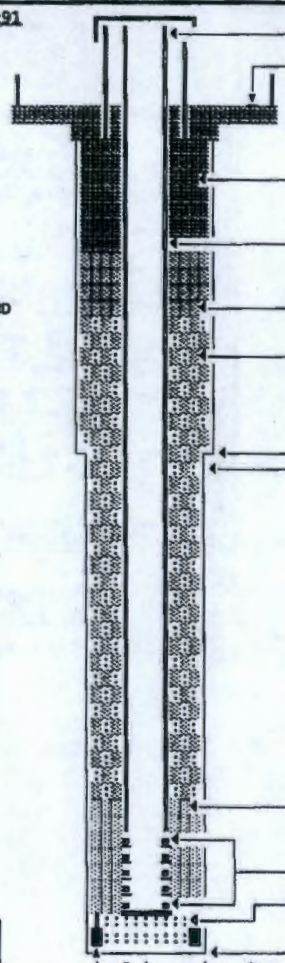
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 08Oct91

WELL NUMBER: 399-1-10B
TEMPORARY WELL NO: 1-10B
Hanford Coordinates: N/S Not documented E/W Not doc
State NAD83 RN 57,067.3 RE 16,033.3
Coordinates: N 116,729.06m E 594,351.09m
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 372.47-ft Brass cap

Depth to water: 37.7-ft 08Oct91 (Ground surface)

GENERALIZED Geologist's STRATIGRAPHY Log

0-8: SAND
8-10: Silty SAND
10-35: Gravelly silty SAND
35-39.4: Sandy GRAVEL
39.4-49.6: Gravelly SAND
49.6-54.7: Sandy GRAVEL
54.7-72: Gravelly SAND
72-73: SILT
73-79.8: Gravelly SAND
79.8-80.1: Gravelly SILT
80.1-98: Gravelly SAND
98-109.8: Slightly gravelly SAND
109.8-113: Gravelly SAND
113-119: SILT



Elevation of reference point: [375.58-ft] (top of inner casing)
Height of reference point above ground surface [3.11-ft]
Depth of surface seal [0-20.3-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad extends 2.5-ft into annulus
Portland cement grout to 20.3-ft
4-in ID T304 stainless steel casing, +1.5-104.5-ft
Bentonite crumbles, 20.3-28.2-ft
Bentonite slurry, 28.2-99.0-ft
Hole diameter, 0-53.0-ft, 10.95-in
53.0-119.0-ft, 8.8-in
Silica sand pack, 99.0-100.8-ft, 40-100-mesh
100.8-114.4-ft, 20-40-mesh
4-in T304 stainless steel screen, 104.5-114.5-ft, #10-slot
Bentonite hole plug, 115.3-119.0-ft
Borehole drilled depth: [119.0-ft]
8-in casing shoe cut off and left in hole, ~117.0-119.0-ft

Drawing By: RKL/3-01-10B.ASB
Date : 31Jan94
Reference : HANFORD WELLS WHC-SD-EN-TI-052

Figure C-2. Well 399-1-10B Construction and Completion Summary

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Amos
Drilling Company: Associated Drillers
Date Started: 01Dec86

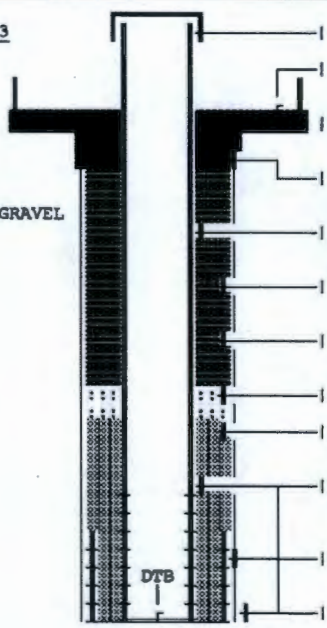
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 1224
Company Location:
Date Complete: 04Dec86

WELL NUMBER: 399-1-16A
TEMPORARY WELL NO: C-1A
Hanford Coordinates: N/S S 23,341 E/W E 14,304
State RN 56,035.6 RE 15,910.1
Coordinates: N Not documented E Not documented
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 380.21-ft Brass cap

Depth to water: 40.0-ft Dec86
(Ground surface) 38.1-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-15: Silty, sandy GRAVEL
15-20: Clayey, sandy GRAVEL
20-30: Silty, sandy GRAVEL
30-35: Silty, gravelly SAND
35-45: Silty SAND with CLAY and GRAVEL
45-TD: Silty, gravelly SAND



Elevation of reference point: [381.51-ft]
(top of casing)
Height of reference point above [1.30-ft]
ground surface

Depth of surface seal [0-5.0-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 5.0-ft

6-in ID stainless steel casing,
+1.3-32.5-ft

Bentonite crumbles,
5.0-21.0-ft

Hole diameter,
0-47.5-ft. 11-in nominal

Bentonite pellets,
21.0-24.8-ft

Silica sand pack,
24.8-47.5-ft, 10-20-mesh

6-in stainless steel screen,
32.5-47.5-ft, #20-slot

10-in telescoping screen,
37.5-47.5-ft, #40-slot

Borehole drilled depth: [47.5-ft]

DTB=Depth to bottom,
47.8-ft, 04Dec90

Drawing By: RKL/3-01-16A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

Figure C-3. Well 399-1-16A Construction and Completion Summary

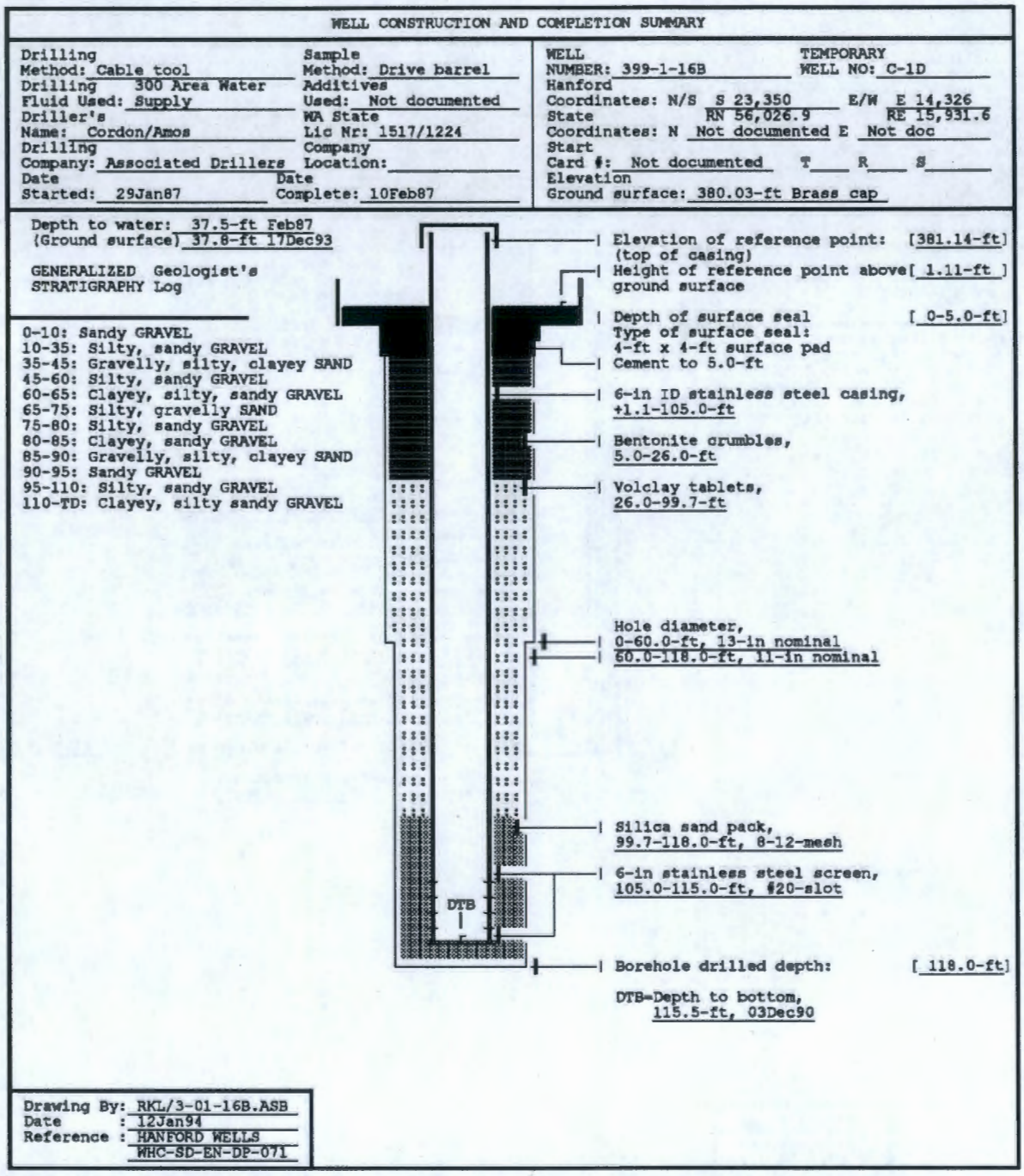


Figure C-4. Well 399-1-16B Construction and Completion Summary

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 08Nov86

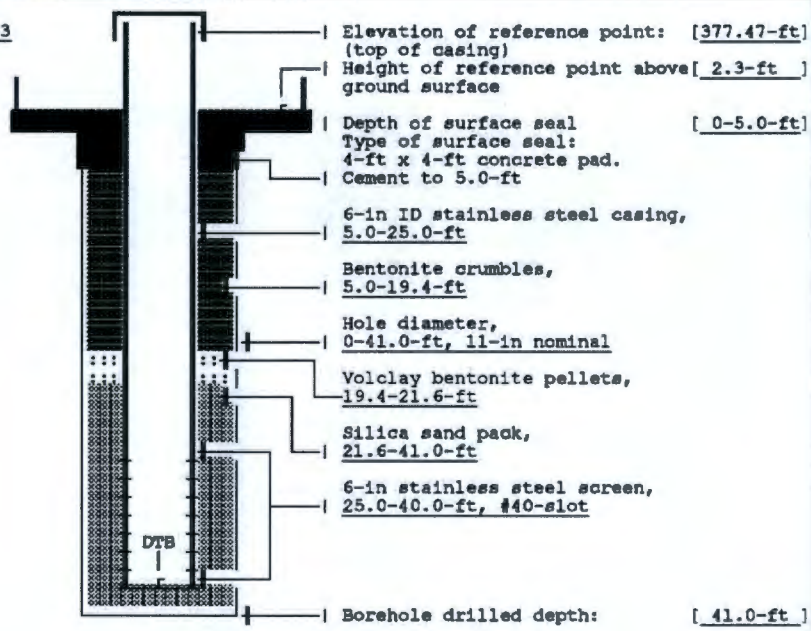
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 13Nov86

WELL NUMBER: 399-1-17A
TEMPORARY WELL NO: C-2A
Hanford Coordinates: N/S S 23,331 E/W E 13,630
State RN 56,045.7 RE 15,236.2
Coordinates: N Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.13-ft Brass cap

Depth to water: 32.3-ft Nov86
(Ground surface) 33.2-ft 17Dec93

GENERALIZED STRATIGRAPHY Geologist's Log

0-10: Sandy GRAVEL
10-25: Silty, sandy GRAVEL
25-35: Silty, gravelly SAND
35-40: Silty SAND



Drawing By: RKL/3-01-17A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

Figure C-5. Well 399-1-17A Construction and Completion Summary

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 01Dec86

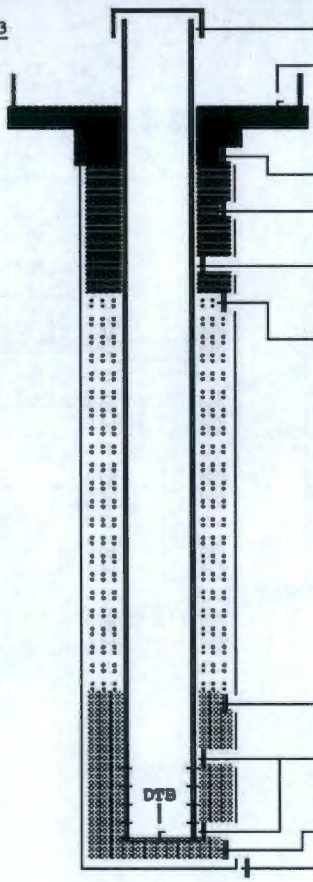
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lid Nr: 1517
Company Location:
Date Complete: 19Dec86

WELL NUMBER: 399-1-17B
TEMPORARY WELL NO: C-2B
Hanford Coordinates: N/S S 23,317 E/W E 13,604
State Coordinates: N RN 56,059.5 E RE 15,210.3
Not documented Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 375.48-ft Brass cap

Depth to water: 32.9-ft Dec86
(Ground surface) 33.3-ft 17Dec93

GENERALIZED STRATIGRAPHY Log
Geologist's Log

0-5: Silty SAND
5-15: Silty, sandy PEBBLES
15-25: Sandy PEBBLES
25-30: Gravelly SAND
30-35: Sandy GRAVEL
35-40: Sandy PEBBLES
40-55: Sandy GRAVEL
55-70: Silty, sandy GRAVEL
70-85: Sandy GRAVEL
85-90: Silty, sandy GRAVEL
90-95: Sandy GRAVEL
95-105: Silty, sandy GRAVEL
105-110: Silty, gravelly SAND
110-115: Sandy, gravelly CLAY



Elevation of reference point: [377.87-ft]
(top of casing)
Height of reference point above ground surface [2.39-ft]
Depth of surface seal [0-4.0-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 4.0-ft
Bentonite crumbles, 4.0-28.0-ft
6-in ID stainless steel casing, +2.4-100.0-ft
Volclay tablets, 20.8-95.0-ft
Silica sand pack, 95.0-113.5-ft, 8-12-mesh
6-in stainless steel screen, 100-110-ft, #40-slot [100.0-ft]
Fill, 113.5-115.0-ft
Borehole drilled depth: [115.0-ft]
DTB=Depth to bottom, 110.2-ft, 03Dec90

Drawing By: RKL/3-01-17B.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

Figure C-6. Well 399-1-17B Construction and Completion Summary

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 06Nov86

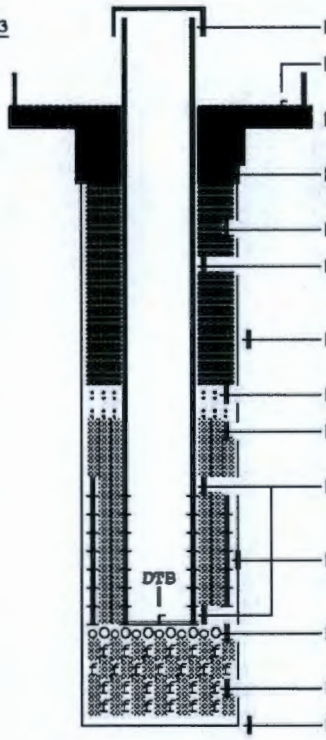
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 12Nov86

WELL NUMBER: 399-1-18A
TEMPORARY WELL NO: C-3A
Hanford Coordinates: N/S N 20,407 E/W E 12,877
State Coordinates: N RN 58,970.1 E RE 14,483.3
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 387.77-ft Brass cap

Depth to water: 47.0-ft Nov86
(Ground surface) 44.9-ft 17Dec93

GENERALIZED STRATIGRAPHY Log
Geologist's

0-5: No record
5-15: Silty SAND
15-35: Gravelly SAND
35-45: Silty, gravelly SAND
45-60: Gravelly SAND with trace of SILT
60-TD: Sandy GRAVEL with trace of SILT and CLAY



Elevation of reference point: [390.83-ft]
(top of casing)
Height of reference point above ground surface [3.06-ft]
Depth of surface seal [0-5.5-ft]
Type of surface seal:
4-ft x 4-ft concrete surface pad
Cement to 5.5-ft
Bentonite crumbles, 5.5-31.8-ft
6-in ID stainless steel casing, +3.1-39.0-ft
Hole diameter, 0-63.0-ft, 11-in nominal
Volclay bentonite pellets, 31.8-34.0-ft
Silica sand pack, 34.0-54.0-ft, 8-12-mesh
6-in stainless steel screen, 39.0-54.0-ft, #40-slot
10-in telescoping screen, 39.0-54.0-ft
Gravel pack to 54.4-ft
Fill, 54.4-63.0-ft
Borehole drilled depth: [63.0-ft]
DTB=Depth to bottom, 53.8-ft, 06Nov90

Drawing By: RKL/3-01-18A.ASB
Date : 12Jan94
Reference : HANFORD WELLS
WHC-SD-EN-DP-071

Figure C-7. Well 399-1-18A Construction and Completion Summary

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 300 Area Water Supply
Driller's Name: Cordon
Drilling Company: Associated Drillers
Date Started: 13Nov86

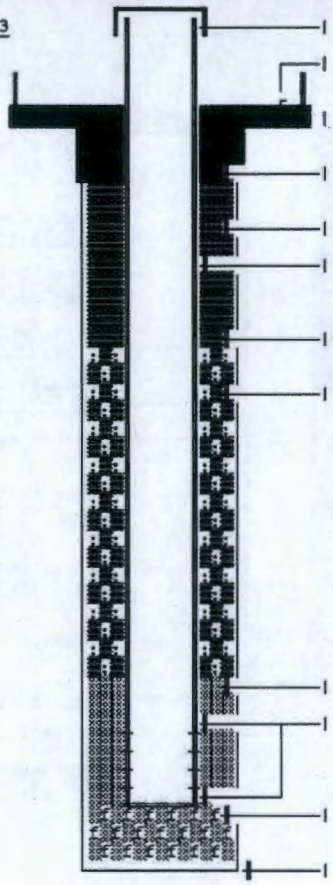
Sample Method: Drive barrel
Additives Used: Not documented
WA State Lic Nr: 0079
Company Location:
Date Complete: 20Jan87

WELL NUMBER: 399-1-18B
TEMPORARY WELL NO: C-3B
Hanford Coordinates: N/S S 20,420 E/W E 12,865
State Coordinates: N RN 58,956.5 E RE 14,470.8 Not documented E Not doc
Start Card #: Not documented T___ R___ S___
Elevation Ground surface: 387.24-ft Brass cap

Depth to water: 42.5-ft Jan87
(Ground surface) 44.0-ft 17Dec93

GENERALIZED STRATIGRAPHY Log — Geologist's Log

0-5: Not documented
5-11: SAND
11-15: SAND and GRAVEL
15-25: Sandy GRAVEL
25-30: Silty, sandy GRAVEL
30-40: Sandy GRAVEL with trace of SILT
40-50: Silty, sandy GRAVEL
50-55: Pebbly SAND
55-60: Sandy, silty GRAVEL
60-65: Pebbly SAND
65-85: Silty, sandy GRAVEL
85-90: Sandy SILT
90-95: Silty, sandy GRAVEL
95-115: Sandy, silty GRAVEL
115-120: Silty, sandy GRAVEL
120-125: Sandy, clayey GRAVEL
125 : Sandy, gravelly CLAY



Elevation of reference point: [389.94 ft] (top of casing)
Height of reference point above ground surface [2.70-ft]
Depth of surface seal [0-5.0-ft]
Type of surface seal: 4-ft x 4-ft concrete surface pad
Cement to 5.0-ft
Bentonite crumbles, 5.0-34.0-ft
6-in ID stainless steel casing, +2.7-108.5-ft
Hole diameter, 0-125.0-ft, 11-in nominal
Volclay grout, 34.0-105.0-ft
Silica sand pack, 105.0-118.0-ft, 8-12-mesh
6-in stainless steel screen, 108.5-118.5-ft, #40-slot
Fill, 118.0-125.0-ft
Borehole drilled depth: [125.0-ft]

Drawing By: RKL/3-01-18B.ASB
Date : 12Jan94
Reference : HANFORD WELLS WHC-SD-EN-DP-071

Figure C-8. Well 399-1-18B Construction and Completion Summary

C2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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Appendix D

Dangerous Waste Corrective Action Monitoring Results

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Figure D-4. Corrective Action Monitoring Results of *cis*-1,2-DCE at Wells 399-1-18A and 399-1-18B D-3

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Terms

cis-1,2-DCE	*cis*-1,2-dichloroethene
TCE	trichloroethene

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D1 Introduction

This appendix presents the corrective action monitoring results of the 300 Area Process Trenches dangerous wastes trichloroethene (TCE), and *cis*-1,2-dichloroethene (*cis*-1,2-DCE) in the groundwater monitoring well network. Corrective action monitoring of 300 Area Process Trenches commenced in 1997. The 300 Area Process Trenches specific concentration limits identified in Part VI, Post-Closure Unit 1 of the Hanford Facility *Resource Conservation and Recovery Act of 1976* Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*) for each dangerous waste are also presented.

The 300 Area Process Trenches corrective action monitoring network comprises four well pairs:

- 399-1-10A, 399-1-10B
- 399-1-16A, 399-1-16B
- 399-1-17A, 399-1-17B
- 399-1-18A, 399-1-18B

Figures D-1 through D-4 present the results of *cis*-1,2-DCE monitoring for each of the well pairs with the concentration limit (16 µg/L) identified in Section 3.2. Figures D-5 through D-8 present the results of TCE monitoring for each of the well pairs with the concentration limit (4 µg/L) identified inSection 3.2.

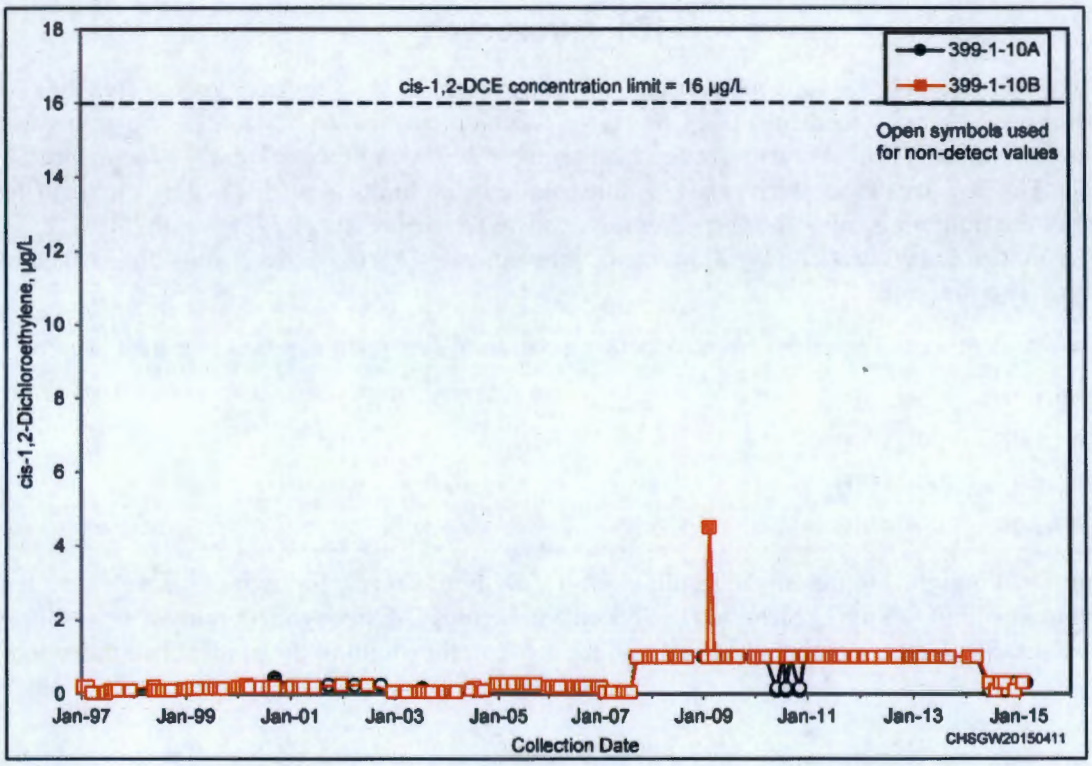

Figure D-1. Corrective Action Monitoring Results of *cis*-1,2-DCE at Wells 399-1-10A and 399-1-10B

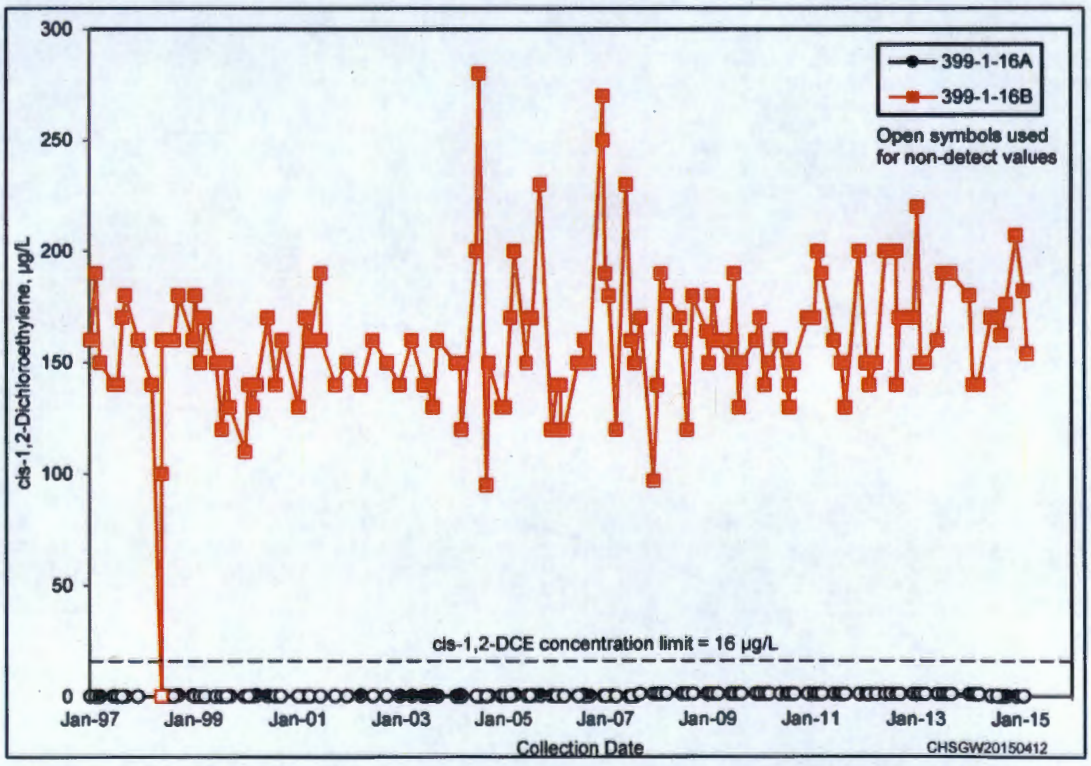

Figure D-2. Corrective Action Monitoring Results of *cis*-1,2-DCE at Wells 399-1-16A and 399-1-16B

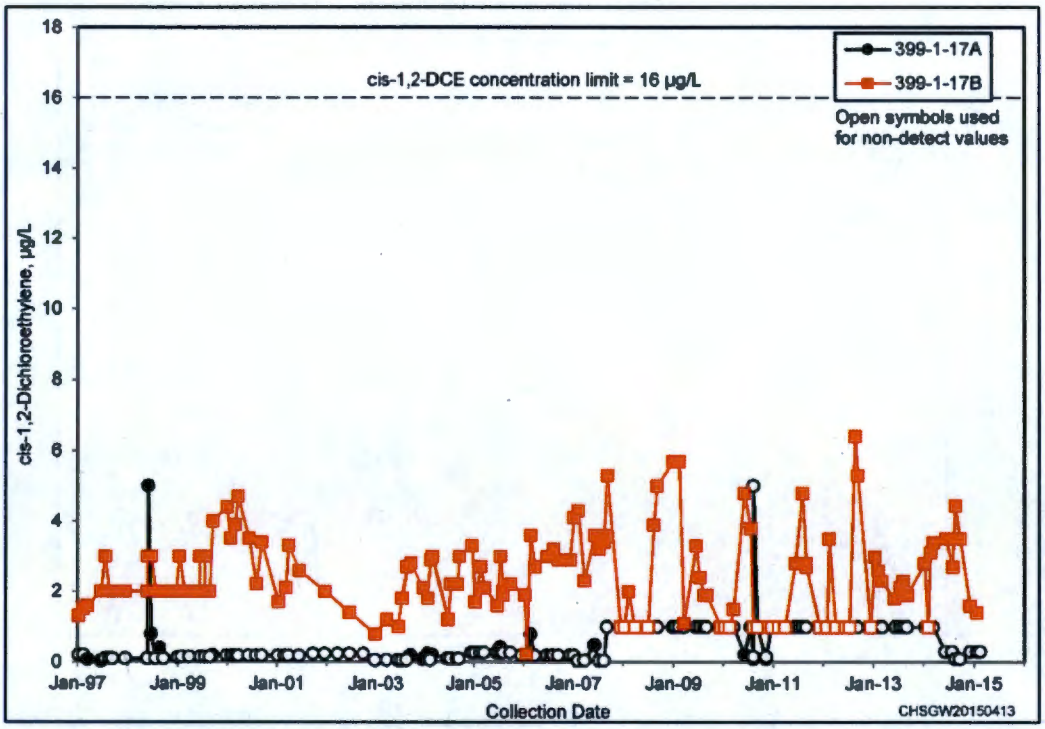

Figure D-3. Corrective Action Monitoring Results of *cis*-1,2-DCE at Wells 399-1-17A and 399-1-17B

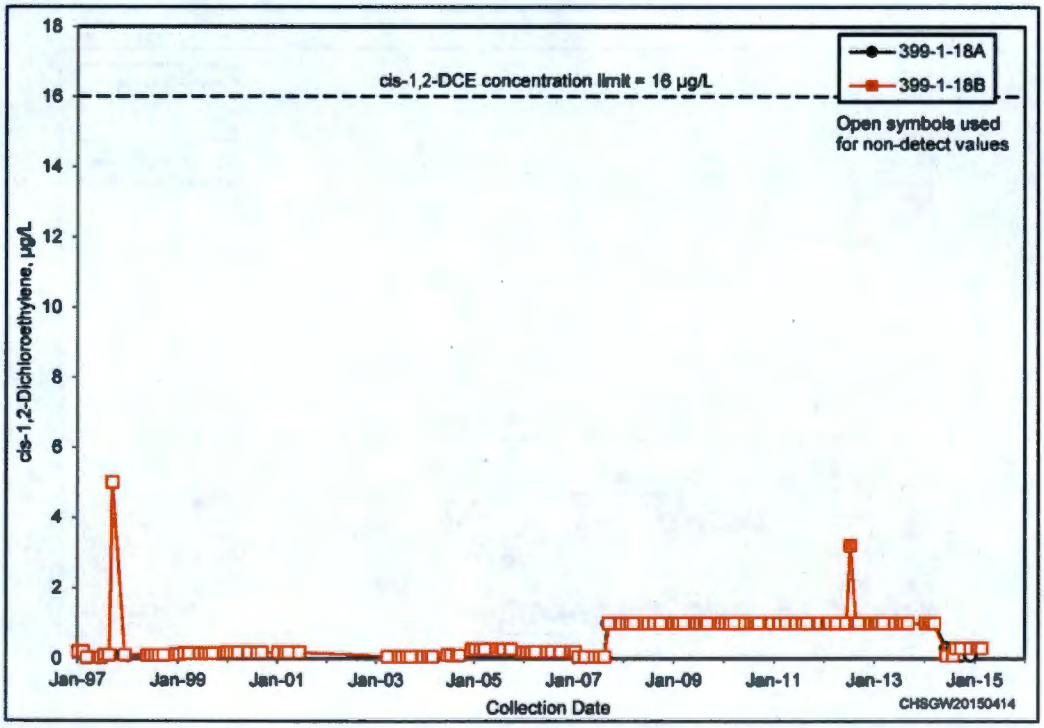

Figure D-4. Corrective Action Monitoring Results of *cis*-1,2-DCE at Wells 399-1-18A and 399-1-18B

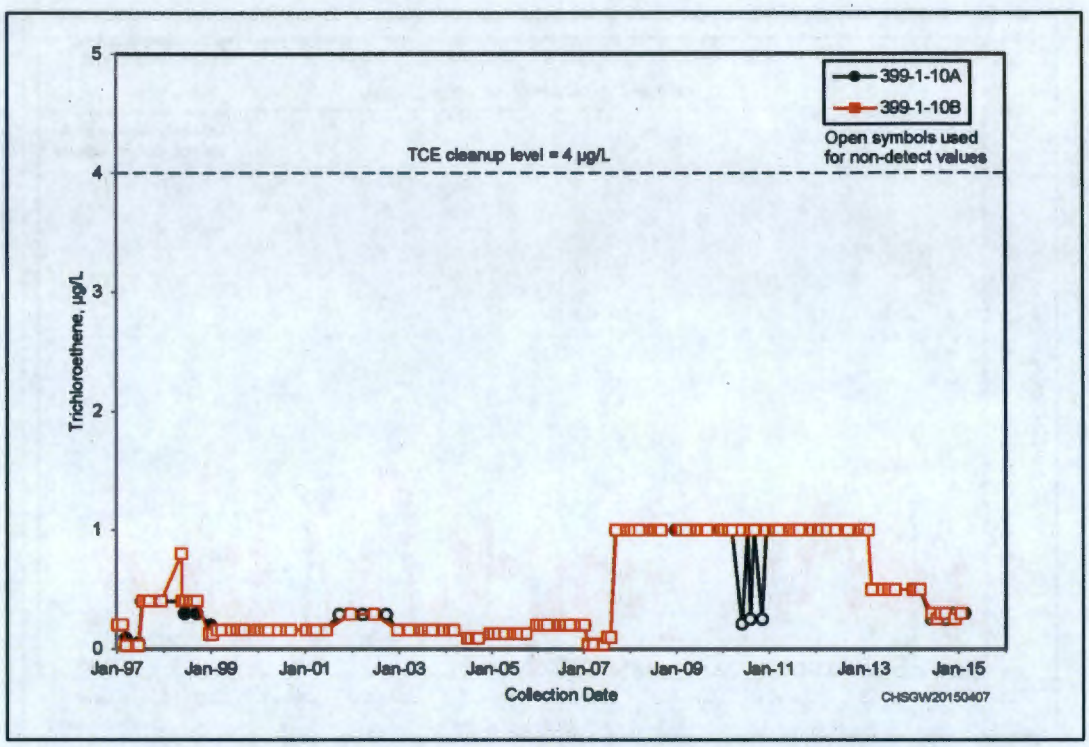

Figure D-5. Corrective Action Monitoring Results of TCE at Wells 399-1-10A and 399-1-10B

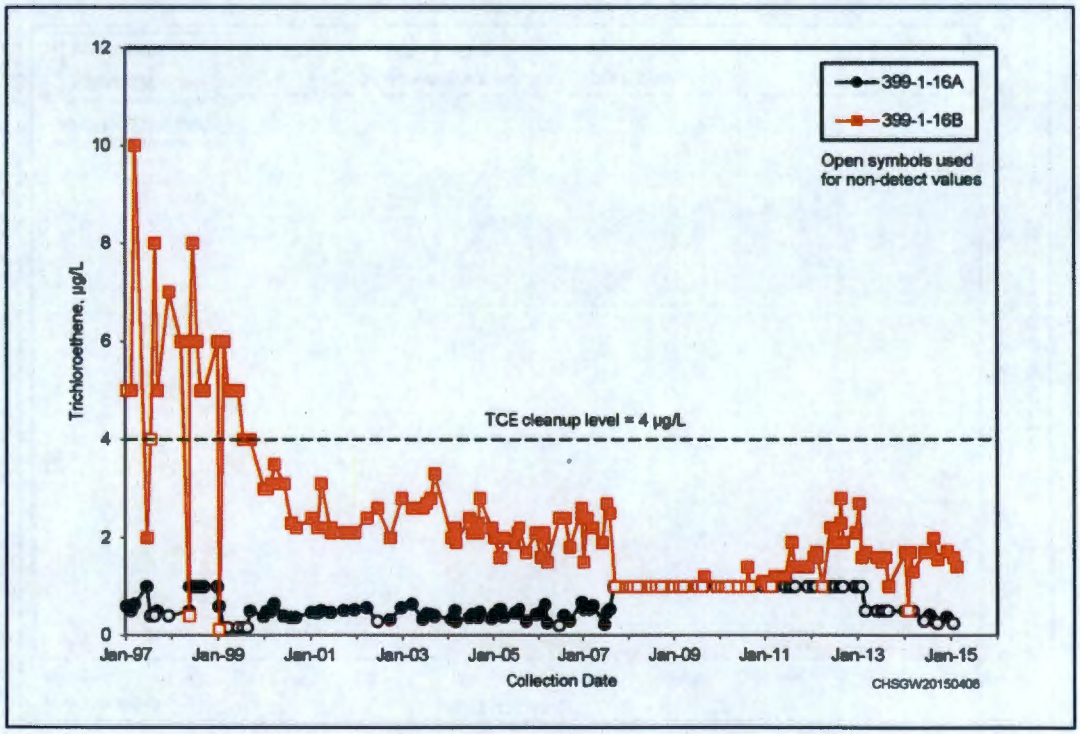

Figure D-6. Corrective Action Monitoring Results of TCE at Wells 399-1-16A and 399-1-16B

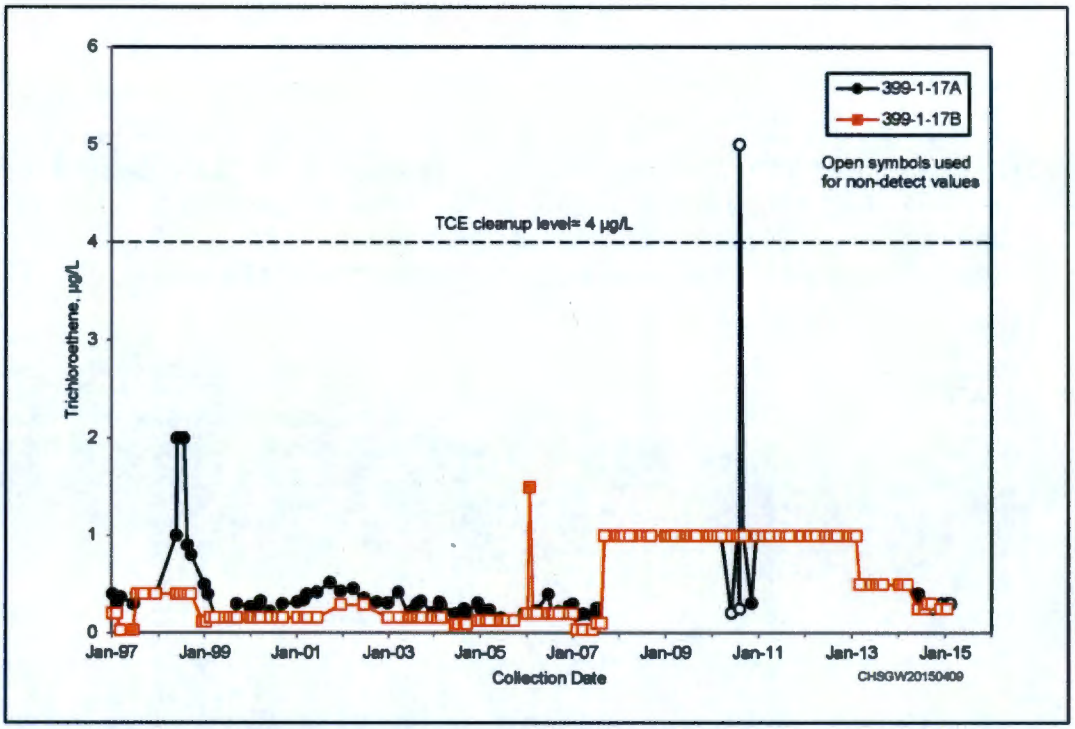

Figure D-7. Corrective Action Monitoring Results of TCE at Wells 399-1-17A and 399-1-17B

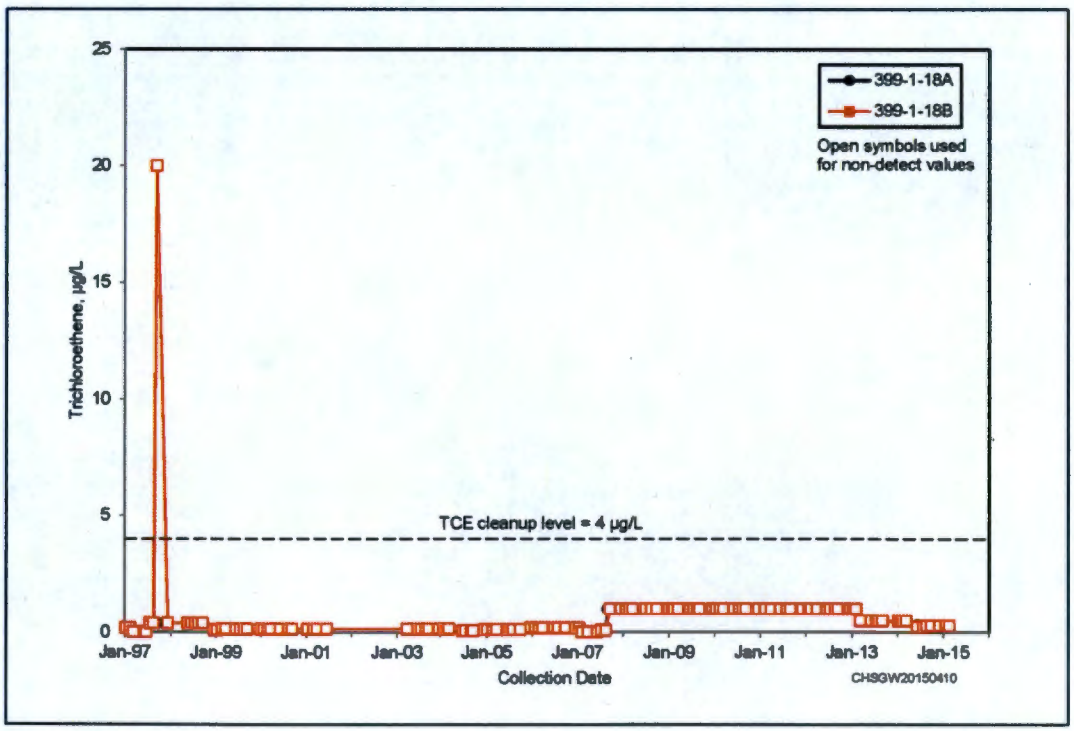

Figure D-8. Corrective Action Monitoring Results of TCE at Wells 399-1-18A and 399-1-18B

D2 References

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epw.senate.gov/rcra.pdf.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/index.html.

ENCLOSURE 2

Changes to 183-H Solar Evaporation Basisns Groundwater Monitoring Plan

Consisting of 156 pages,
including this cover page

Hanford Facility RCRA Permit Modification Notification Forms

Parts VI, 183-H Solar Evaporation Basins, Post Closure Unit Group 2 (PCU-2)

Index

Page 2 of 3 Chapter 3.0 (Groundwater Monitoring Plan)
Page 3 of 3 Revision Instructions

Hanford Facility RCRA Permit Modification Notification Form	
Unit: **183-H Solar Evaporation Basins, Post Closure Unit Group 2 (PCU-2)**	Permit Part **Part VI (PCU-2)** **Chapter 3.0 (Groundwater Monitoring Plan)**

Description of Modification:

Chapter 3.0 (Groundwater Monitoring Plan) - The proposed changes to the Groundwater Monitoring Plan are substantial. Hence, a red-line/strike-out version of the changes is impractical. The Groundwater Monitoring Plan currently in the permit (PNNL-11573) is being replaced, in its entirety, with a new plan (DOE/RL-2015-28, REV. 0). The new plan revises the constituents to be monitored, sampling frequency, concentration limits, statistical evaluation processes, and the compliance period.

WAC 173-303-830 Modification Class	Class 1	Class 1	Class 2	Class 3
Please mark the Modification Class:			X	

Enter relevant WAC 173-303-830, Appendix I Modification citation number: Per WAC 173-303-830(4)(d), the Permittee requests that this modification be reviewed and approved as a Class 2.

Revision Instructions:

Remove PCU-2, Chapter 3.0 Groundwater Monitoring Plan (PNNL-11573) and replace with the new plan provided herein (DOE/RL-2015-28, REV. 0).

183-H SOLAR EVAPORATION BASINS
CHAPTER 3.0
GROUNDWATER MONITORING

CHANGE CONTROL LOG

Change Control Logs ensure that changes to this unit are performed in a methodical, controlled, coordinated, and transparent manner. Each unit addendum will have its own change control log with a modification history table. The "**Modification Number**" represents Ecology's method for tracking the different versions of the permit. This log will serve as an up to date record of modifications and version history of the unit.

Modification History Table

Modification Date	Modification Number
08/13/2013	

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CHAPTER 3.0
GROUNDWATER MONITORING

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CHAPTER 3.0
GROUNDWATER MONITORING

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3.0 GROUNDWATER MONITORING DURING POSTCLOSURE

Groundwater concentration limits have been exceeded for dangerous waste constituents in downgradient monitoring wells at 183-H Solar Evaporation Basins. Washington Administrative Code (WAC) 173-303-645(11) requires that a corrective action program be established in the Permit to (1) address the contamination, and (2) monitor the effectiveness of the action (Rasmussen 1996c). This post-closure plan, along with a revised groundwater monitoring plan (Hartman 1997), describes current and future actions to satisfy this requirement.

Corrective action to address groundwater contamination in the 100-H Area, including contamination that has resulted from 183-H Solar Evaporation Basins, has been initiated as part of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation activities. An Interim Remedial Measure (IRM) to remove hexavalent chromium will begin extracting groundwater from wells located in the vicinity of the former 183-H in July 1997 (DOE-RL 1996b). The IRM pumping system will change local hydraulic gradients and the direction of groundwater flow.

Not all of the dangerous waste constituents attributable to 183-H Solar Evaporation Basins are specifically targeted by the IRM treatment system. The primary treatment target is chromium. However, nitrate and two nondangerous waste constituents, technetium-99 and uranium, are also likely to be retained on the ion exchange columns, although hexavalent chromium will be preferentially retained. The IRM corrective action is the first phase of groundwater remediation in the 100-H Area, with subsequent phases to be determined by the feasibility study process under CERCLA. A final Record of Decision (ROD) will be established using information gained during the IRM for chromium.

Figure 3.1 shows the locations of existing groundwater monitoring wells in the 100-H Area. Figure 3.2 illustrates the changes to groundwater flow that are expected to occur during IRM pumping operations. In general, flow direction will change from an easterly to a more northerly direction beneath the former 183-H Solar Evaporation Basins. Changes in water quality, as observed in monitoring wells influenced by the pumping operation, are also expected to occur. Figure 3.3 provides a recent interpretation showing the distribution of chromium contamination in the 100-H Area.

Because of the corrective action pumping operations, the list of "point of compliance" wells per WAC 173-303-645 requirements will change from the definition presented in the 183-H compliance monitoring plan (Hartman and Chou 1995). Also, the change in flow direction may result in variable concentrations for the dangerous waste indicators in the wells previously identified as points of compliance. Therefore, a revised groundwater monitoring plan has been prepared (Hartman 1997) that reflects corrective action monitoring requirements.

The following sections outline the requirements for groundwater monitoring during corrective action and present a sampling and analysis schedule for meeting the requirements. The sampling and analysis schedule for RCRA corrective action requirements becomes a condition of the revised Permit. Other sampling and analysis activities within the 100-H Area are also described for general information purposes only.

3.1 WAC 173-303-645(11)(d) Monitoring Requirements

The WAC 173-303-645(11) Corrective Action Program requires the establishment and implementation of a groundwater monitoring program that is capable of demonstrating the effectiveness of the corrective action. This requirement states two general objectives:

- The program may be based on the requirements for a compliance monitoring program under WAC 173-303-645(10) and must be as effective as that program in determining compliance with the groundwater protection standard under WAC 173-303-645(3). A compliance monitoring program that met the objectives of the groundwater protection standard was established and adopted within the Permit (Hartman and Chou 1995).

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- Monitoring during corrective actions must be capable of determining the success of the corrective action program. A revised groundwater monitoring plan has been prepared to reflect corrective action requirements (Hartman 1997). Also, as part of the IRM to address chromium contamination, a performance monitoring program has been designed and implemented to evaluate the effectiveness of the pump-and-treat system (DOE-RL 1997).

The following sections demonstrate how the corrective action monitoring requirements in WAC 173-303-645(11) will be met in the 183-H Corrective Action Groundwater Monitoring Plan and 183-H Post-Closure Plan.

3.1.1 WAC 173-303-645(3) Groundwater Protection Standard

Washington Administrative Code 173-303-645(3) introduces the principal requirements that must be met to comply with the Dangerous Waste Regulations for releases from regulated units. It refers to WAC 173-303-645(4) Dangerous Constituents, WAC 173-303-645(5) Concentration Limits, WAC 173-303-645(6) Point of Compliance, and WAC 173-303-645(7) Compliance Period. The Groundwater Protection Standard for the regulated unit has been established by Washington State Department of Ecology (Ecology) in the facility Permit.

3.1.1.1 WAC 173-303-645(4) Dangerous Constituents

Dangerous waste constituents were identified in the 183-H Compliance Monitoring Plan (Hartman and Chou 1995). They are hexavalent chromium, as represented by an analysis for total chromium using filtered samples, and nitrate.

Additional waste indicators used to define the contaminant plume attributable to 183-H are technetium-99 and uranium. Wastes from 183-H basins' leakage may have altered various other water quality parameters that are not regulated, but are useful for identifying and tracking contamination from 183-H Solar Evaporation Basins (e.g., specific conductance). Because fluoride was discovered to be elevated in the soil at the bottom of the excavation beneath the 183-H footprint (along with nitrate), fluoride will also be used as an indicator for 183-H contamination in groundwater.

All of the above constituents of interest will be monitored under the revised plan for corrective action groundwater monitoring (Hartman 1997).

3.1.1.2 WAC 173-303-645(5) Concentration Limits

Dangerous waste constituents from the regulated waste unit may not exceed concentration limits established by the Permit. Permit limits were defined previously in the 183-H Compliance Monitoring Plan (Hartman and Chou 1995). Concentration limits established for the 183-H groundwater plume were as follows:

Dangerous Waste Constituents	
Chromium (total; filtered sample)	122 µg/L--local background; upgradient sources
Nitrate	45,000 µg/L--EPA MCL for drinking water
Other 183-H Waste Indicators	
Technetium-99	900 pCi/L--EPA MCL for drinking water
Uranium (total; chemical analysis)	20 µg/L--EPA MCL--proposed

During the period of time that the IRM to address chromium is extracting groundwater, the corrective action monitoring described in the revised groundwater monitoring plan (Hartman 1997) will continue to evaluate new analytical results relative to these concentration limits. Additionally, fluoride results will be evaluated relative to previously established trends and to the U.S. Environmental Protection Agency (EPA) Maximum Containment Levels (MCL) for drinking water, which is 1,400 µg/L.

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3.1.1.3 WAC 173-303-645(6) Point of Compliance

"The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated unit." Operation of the IRM groundwater extraction network will alter the pattern of groundwater flow. Therefore, the relative positions (i.e.,. upgradient, downgradient) for some of the monitoring wells used to establish the point of compliance listed in the 183-H Compliance Monitoring plan (Hartman and Chou 1995) will change (Section 3.2).

A new list of wells has been defined to act as points of compliance while the IRM is operating. The new list was developed at a workshop held on March 5, 1997 using the EPA Data Quality Objectives (DQO) process. The points of compliance identified at the workshop were subsequently approved by Ecology on April 22, 1997 via letter (Soper 1997b). The wells are identified in the revised groundwater monitoring plan for corrective action monitoring (Hartman 1997) (Section 3.2).

3.1.1.4 WAC 173-303-645(7) Compliance Period

The modified RCRA network and sampling schedule will be in effect during groundwater extraction operations that are conducted as part of the IRM for chromium. Based on the observed impact that the IRM has on groundwater flow patterns and water quality after operations begin, further modifications to the RCRA network may be appropriate during and following the IRM. This post-closure plan and the revised groundwater-monitoring plan for corrective action monitoring will be revised and incorporated into a permit modification, as necessary.

Following cessation of groundwater extraction operations under the IRM, RCRA monitoring under the final status monitoring plan (Hartman, 1997) will continue for a minimum of three consecutive years (WAC 173-303-645(7)(c) to demonstrate that the groundwater protection standards of WAC 173-303-645(3) have been met. This monitoring will complement monitoring conducted to (1) evaluate the performance of the IRM and (2) support selection of a final remediation alternative.

3.1.2 WAC 173-303-645(8) General Groundwater Monitoring Requirements

The requirements described in WAC 173-303-645(8) will be met as described in the *183-H Corrective Action Monitoring Plan* (Hartman, 1997). Newly collected data will be reported quarterly and an evaluation of monitoring data will be reported in the Annual Groundwater Project Report for the Hanford Site (e.g., Hartman and Dresel 1997).

3.2 RCRA Corrective Action Groundwater Monitoring Schedule

The *183-H Compliance Monitoring Plan* (Hartman and Chou 1995) has been revised (Hartman 1997) to accommodate changes in (1) the groundwater flow pattern and (2) concentrations of selected waste indicators, which are brought on by pump-and-treat remediation activities. The EPA Data Quality Objectives process (EPA 1994) was followed to help design the revised sampling and analysis schedule. Representatives from RL, Ecology, and EPA reached consensus on objectives, wells to be sampled, constituents for analysis, sampling frequency, and water level measurements (Furman 1997).

The resulting schedule for the 183-H Solar Evaporation Basins RCRA network is presented in Table 3.1. This table identifies the wells being sampled, the frequency of sampling, and an analysis suite code for the previous RCRA compliance monitoring schedule and for the revised corrective action monitoring schedule. Table 3.2 provides a complete description of the constituent analysis suites. Information on sampling schedules under CERCLA is included in the Tables, to provide a complete description of all groundwater-monitoring activities being conducted in the vicinity of the former 183-H Solar Evaporation Basins.

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The RCRA sampling and analysis schedule includes a network of four wells sampled annually. The wells are 199-H4-8, 199-H4-12A, 199-H4-12C, and 199-H4-84 (Figure 3.1). (Well 199-H4-12C is also used as an extraction well for the pump-and-treat system.) Water samples will be analyzed for the constituents of concern previously identified for tracking contamination attributable to the 183-H Solar Evaporation Basins (nitrate, fluoride, chromium, uranium, and technetium-99). Additional analyses will be performed for alkalinity, other anions, and other metals, to aid in interpreting results. Field parameters (pH, temperature, specific conductance, and turbidity) will also be measured.

Minor modifications to the list of specific wells used and constituents analyzed may be appropriate to account for changing field conditions, IRM operational requirements, and changes identified during the data evaluation process. Recommendations for minor modifications will be presented for regulator approval outside of the permit modification process prior to implementation.

3.3 Groundwater Monitoring Under CERCLA

Groundwater underlying the former 183-H Solar Evaporation Basins is included in the 100-HR-3 Operable Unit. This groundwater operable unit contains the groundwater underlying the 100-D/DO Area, 100-H Area, and the 600 Area in between. Along the Columbia River, the boundary of the operable unit is generally accepted as the interface between groundwater discharging from the aquifer and river water. Samples of riverbank seepage and of pore water from riverbed sediment are used to monitor the interface.

3.3.1 100-HR-3 Remedial Investigation Monitoring

The remedial investigation was initially guided by a work plan (DOE-RL 1992) that directed a limited field investigation. A limited field investigation report, which includes a qualitative risk assessment, was prepared (DOE-RL 1994). A focused feasibility study was subsequently conducted that looked at various remediation alternatives to address chromium contamination, and to help decide whether interim remedial measures were warranted (DOE-RL 1995a). A proposed plan (DOE-RL 1995b) and Record of Decision (EPA 1996) were then prepared that described a pump-and-treat alternative to address chromium in the 100-HR-3 and 100-KR-4 Operable Units.

In addition to chromium, other groundwater constituents in the 100-H Area remain above EPA drinking water standards and/or Washington State cleanup levels (Peterson et al. 1996). Chemical constituents include aluminum, fluoride, iron, manganese, nitrate, and uranium. Radiological constituents include gross alpha, gross beta, strontium-90, and technetium-99. None of these constituents have been designated as contaminants of concern for interim remedial measures, by reason of human health or ecological risk.

Sampling under the remedial investigation is typically conducted annually, with some wells being monitored quarterly for selected constituents, and others being sampled once every two years. Biennial sampling is conducted where two wells monitor essentially the same conditions, but each well is sampled on alternate years. The schedule for remedial investigation monitoring well sampling for Fiscal Year (FY) 1997 and FY 1998 is included in Table 3.1.

3.3.2 100-HR-3 Interim Remedial Measure Monitoring

A decision was made in 1996 to proceed with accelerated remediation activities to remove hexavalent chromium (Cr+6) from groundwater underlying the 100-HR-3 Operable Unit (DOE-RL 1995b; EPA 1996). The activities involve pumping groundwater from wells located near the river and removing chromium using an ion exchange resin (DOE-RL 1996a). In the 100-H Area, two additional inland wells were added to the extraction network to intercept chromium migrating into the 100-H Area from sources located to the west. The treated effluent will be reinjected into the unconfined aquifer at an upgradient inland location. Operation of the pump-and-treat system is scheduled to start in July 1997. As stated in the ROD (EPA 1996), the remedial action objectives for the pump-and-treat system include the following three components:

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- Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River (Note: The ROD identifies Cr+6 as the target contaminant).
- Protect human health by preventing exposure to contaminants in the groundwater.
- Provide information that will lead to the final remedy.

The relevant standard for meeting these objectives during the IRM is the State of Washington's Ambient Water Quality Standard (AWQS) for Protection of Freshwater Aquatic Life for hexavalent chromium, which is 11 µg/L for chronic exposure (WAC 173-201A-040). The highest priority contaminated areas to be addressed initially by the remedial action are adjacent to riverbed substrate that is known to provide suitable habitat for salmon spawning. Some of these areas have been defined by direct observation of riverbed substrate and sediment pore water analysis (Hope and Peterson 1996a and 1996b).

In addition to chromium, other contaminants of concern in the 100-H Area that were identified in the ROD (EPA 1996) are nitrate, strontium-90, technetium-99, and uranium. With the exception of strontium-90, the ion exchange treatment system is expected to reduce concentrations of all these contaminants. Tritium may also be present in the extracted water; however, tritium concentrations in 100-H Area wells have decreased to below drinking water standards (Peterson et al. 1996).

3.3.2.1 Data Quality Objectives for IRM Monitoring

Groundwater sampling and analysis activities associated with the IRM for chromium (DOE-RL 1997) serve two general purposes: (1) Performance monitoring to determine the effectiveness and efficiency of the extraction system, and (2) compliance monitoring to show how well the remediation is doing relative to target goals described in the ROD (EPA, 1996).

The objectives for performance monitoring are to collect water level and water quality data that are used to (1) optimize the performance of the groundwater extraction system; (2) document aquifer and chromium plume response to pumping and injection of treated effluent, and (3) obtain supplemental data to support selection of a final remediation alternative for the 100-HR-3 Operable Unit.

Objectives for compliance monitoring are described in the interim ROD (EPA, 1996), which states that monitoring will be conducted at near-river onshore locations that are above the river's high water line. Sampling will be conducted at multiple depth intervals at compliance locations. A dilution factor of 1:1 is allowed when demonstrating compliance with the WAC AWQS of 11 µg/L in riverbed sediment. That is, 22 µg/L at compliance locations is deemed equivalent to 11 µg/L at depths in riverbed substrate of up to 46 cm. Locations initially designated to serve as compliance monitoring points are wells 199-H4-4, 199-H4-5, 199-H4-49, 199-H4-63, and 199-H4-64.

3.3.2.2 IRM Monitoring Wells and Sampling Schedules

The groundwater monitoring wells used to support the interim remedial measures include extraction wells, injection wells, performance monitoring wells, and compliance monitoring wells. The wells are used to obtain water quality data and water level measurements. The schedules for sampling and analysis of these wells are described in Table 3.1 with the analysis listed in Table 3.2. The tables summarize the sampling and analysis schedules for the IRM network as it is planned for FY 1997 and FY 1998. These schedules are subject to change as the result of information gained during the IRM. The schedule for water level measurements is provided in Table 3.3.

3.4 Inspection, Maintenance, and Replacement of Wells

Each time a well is sampled by any of the Hanford Site groundwater monitoring programs, the wellhead, cap, protective posts, and concrete pad are inspected. If the samplers experience problems with dedicated sampling pumps, excessive turbidity in the sample, etc., these problems are noted and maintenance is scheduled.

Periodic maintenance and rehabilitation are generally performed on Hanford Site monitoring wells at five-year intervals.

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This includes removing dedicated equipment, brushing the well bore, removing sediment accumulation, conducting a downhole video camera survey, responding to service difficulty reports, and reinstalling dedicated equipment. A comprehensive description of well maintenance, reconfiguration, and decommissioning is presented in Chapter 8 of the Hanford Site Annual Groundwater Monitoring Report for FY 1996 (Hartman and Dresel 1997).

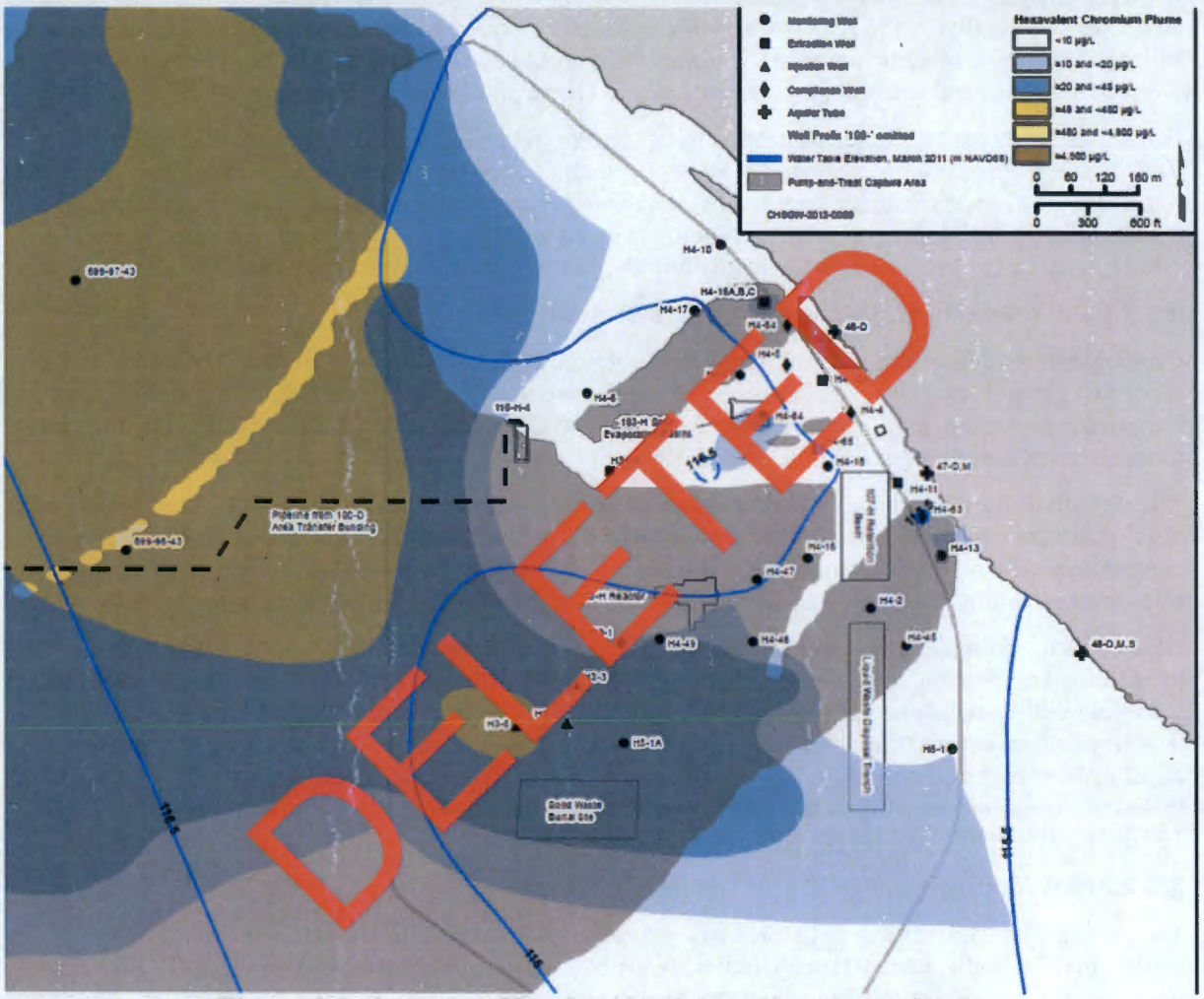
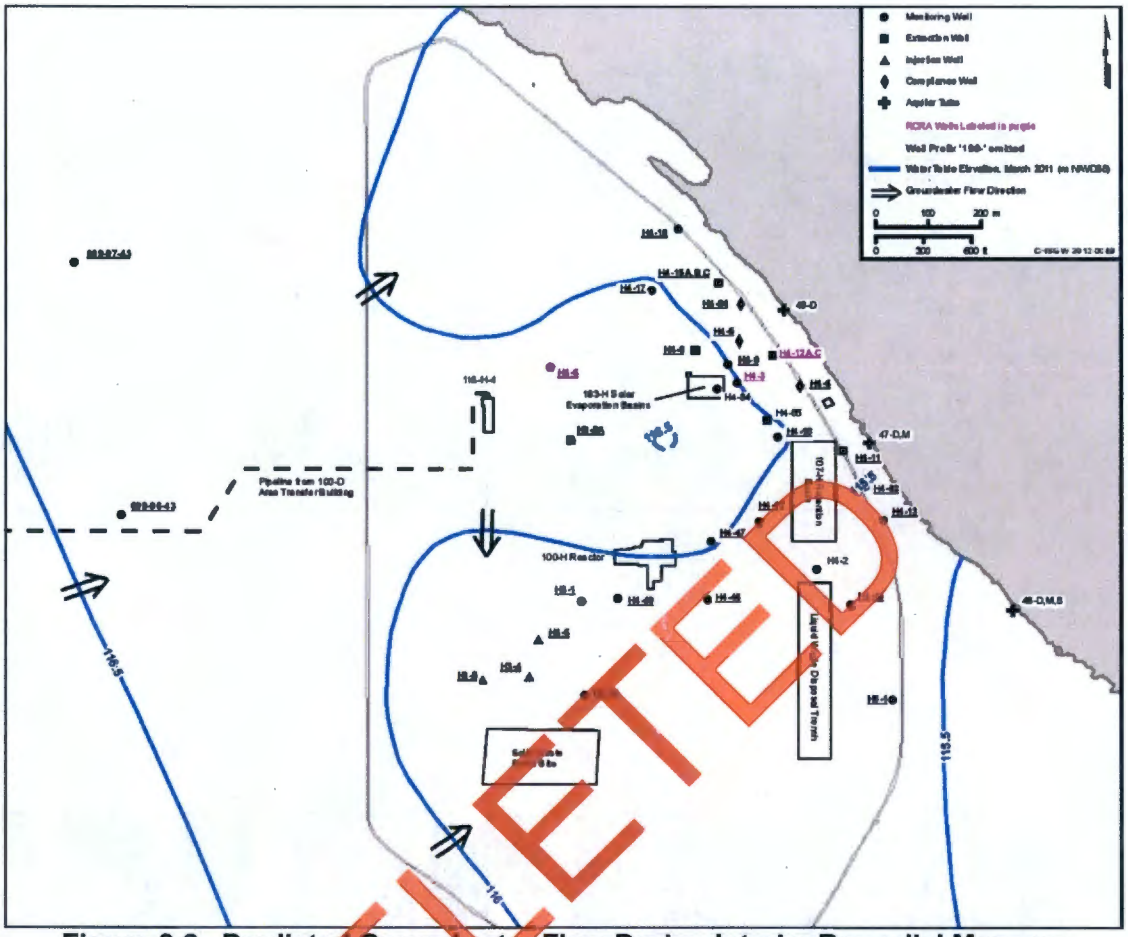


Figure 3.1. Location Map for 100-H Area Monitoring Wells



1 **Figure 3.2. Predicted Groundwater Flow During Interim Remedial Measure**

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Figure KNT-H1 100-H Area Historic Chromium Disribution

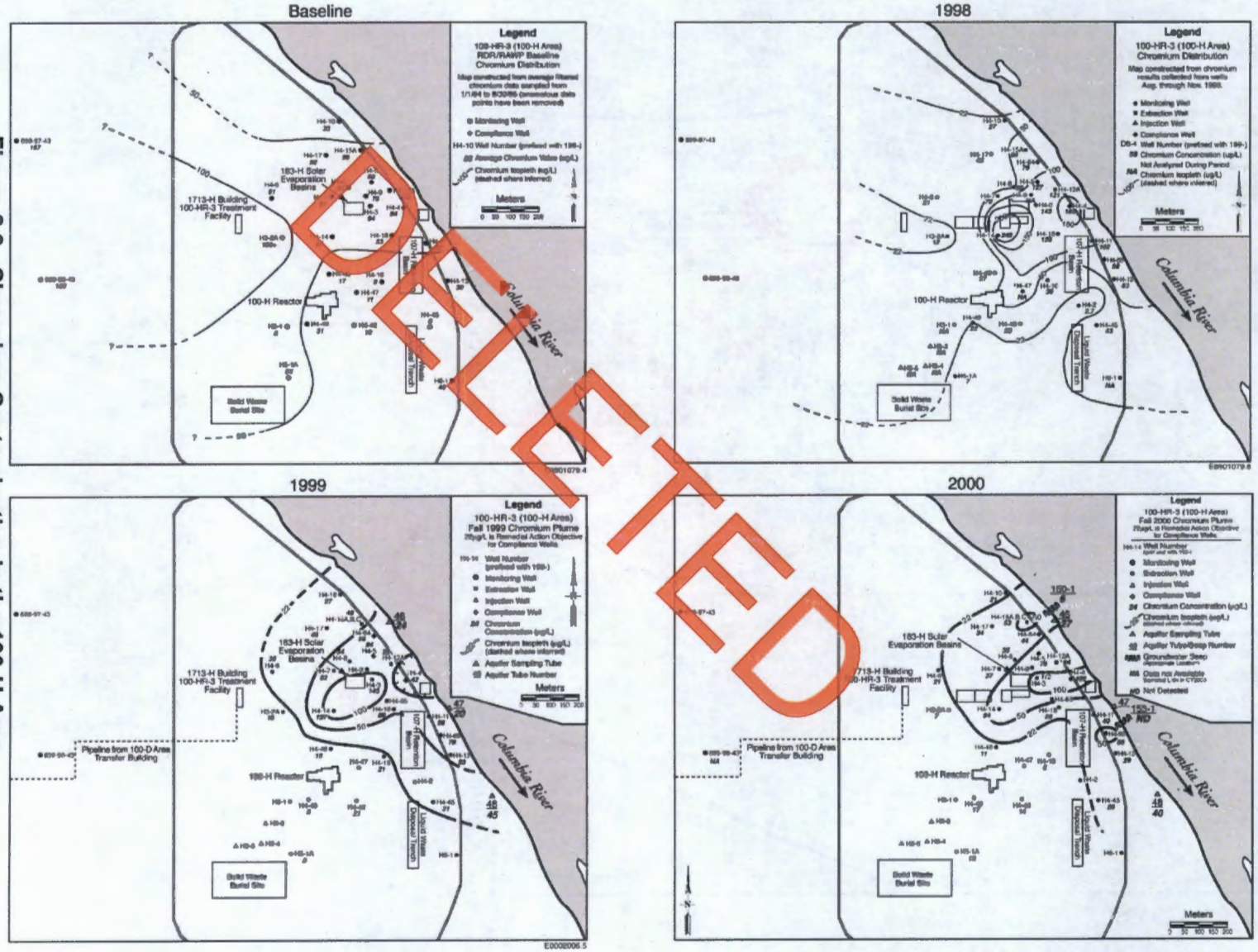

Figure 3.3. Chromium Contamination in the 100-H Area

Table 3.1. Sampling and Analysis Schedule for 183-H Solar Evaporation Basins RCRA Corrective Action & CERCLA Remedial Investigation Monitoring

Well/Location Identifier	Facility Monitored/Purpose	RCRA:		CERCLA Remediation Activities:		
		183-H: Compliance (Pre-IRM[1])	183-H: Corrective Action [2]	RI/FS[3] Round 11: FY 97	Outlook[3] Round 12: FY 98	IRM Monitor Plan[4]
199-H3-1	Reactor building				BA(98)-2	
199-H3-2A	D-plume migration/ IRM extraction well	SA-1		A-2	A-2	SA-3 Q-Cr
199-H3-2C (deep conditions)	D-plume migration/ vertical distribution				BA(98)-2	
199-H4-3	183-H basins/IRM performance	SA-1	A-1	BA(97)-2		SA-Cr
199-H4-	183-H basins/IRM compliance	SA-1		A-2	A-2	M-Cr
199-H4-5	183-H basins/IRM compliance				BA(98)-2	M-Cr
199-H4-6	D-plume migration/ IRM performance	SA-1		BA(97)-2		SA-Cr
199-H4-8	183-H basins/IRM extraction		A-1			SA-3 Q-Cr
199-H4-8	183-H basins/IRM performance			BA(97)-2		SA-Cr
199-H4-9	183-H basins	SA-1			BA(98)-2	
199-H4-10	D-plume migration/ IRM performance			A-2	A-2	SA-Cr
199-H4-11	Retention basins/ IRM extraction					SA-3 Q-Cr
199-H4-12A	183-H basins/ IRM extraction	SA-1	A-1			SA-3 Q-Cr
199-H4-12B	183-H basins/ IRM performance					SA-Cr
199-H4-12C (deep conditions)	183-H basins/ IRM performance	SA-1	A-1	A-2	A-2	SA-Cr
199-H4-13	Retention basins/ IRM performance			A-2	A-2	SA-Cr
199-H4-14	190-H coolant prep/ IRM performance			BA(97)-2		SA-Cr
199-H4-15A	D-plume migration/ IRM extraction					SA-3 Q-Cr
199-H4-15B	D-plume migration/ IRM performance					SA-Cr
199-H4-15CS (deep conditions)	D-plume migration/ IRM performance					SA-Cr
199-H4-16	Reactor building/ IRM performance			BA(97)-2		SA-Cr

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Well/Location Identifier	Facility Monitored/Purpose	RCRA:		CERCLA Remediation Activities:		
		183-H: Compliance (Pre-IRM[1])	183-H: Corrective Action [2]	RI/FS[3] Round 11: FY 97	Outlook[3] Round 12: FY 98	IRM Monitor Plan[4]
199-H4-17	D-plume migration/ IRM performance			BA(97)-2		SA-Cr
199-H4-18	183-H basins/ IRM performance	SA-1		A-2	A-2	SA-Cr
199-H4-45	Liquid waste disposal trench/ IRM performance			A-2	A-2	SA-Cr
199-H4-46	Reactor building/ IRM performance			BA(97)-2		SA-Cr
199-H4-47	Reactor building				BA(98)-2	
199-H4-48	Reactor building/ IRM performance				BA(98)-2	SA-Cr
199-H4-49	Reactor building/ IRM compliance				BA(98)-2	SA-Cr
199-H4-84	183-H basins/IRM compliance	SA-1		A-2	A-2	M-Cr
199-H5-1A	118-H-1 solid waste burial/IRM performance				BA(98)-2	SA-Cr
199-H6-1	Liquid waste disposal trench			A-2	A-2	
199-H4-63 (new well FY97)	IRM compliance					M-Cr
199-H4-64 (new well FY97)	IRM compliance					M-Cr
699-96-43	D-plume migration/ background			BA(97)-2		
699-97-43	D-plume migration/ background				BA(98)-2	

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Sampling code abbreviations: 'BA' = biennial (next year), 'A' = annual, 'SA' = semiannual, 'Q' = quarterly, and 'M' = monthly. The '-1, -2, -3' suffixes define the analysis suite (Table 3.2). 'Q-Cr' indicates quarterly screening for chromium, Sr-90, etc. '(+Tc-99) ' indicates constituent added to basic suite listed in Table 3.2.

Footnotes (References):

1. *183-H Compliance* (183-H compliance groundwater monitoring plan - Hartman and Chou, 1995)
2. *183-H Corrective Action* (183-H corrective action groundwater monitoring plan - Hartman, 1997)
3. *RI/FS Round #11 and #12 Outlook* reflect Tri-Party Agreement Change Control Form #107, November 1996
4. *IRM Monitoring Plan* is for post-July 1997 (IRM Monitoring Plan [DOE-RL 1997])

1

Table 3.2. Analysis Suite Codes for 183-H RCRA Corrective Action & CERCLA Remedial Investigation Monitoring

Analysis/ Parameter	Constituent Code #1 (RCRA: FY97/98)[1]	Constituent Code #2 (RI Round 11&12--FY97/98)[2]	Constituent Code #3 (IRM--FY97/98)[3]
Metals by routine ICP (SW 846 6010B/C, SW 846 6020, or EPA/600/R-94/111, 200.8 - Target Analyte List Note: Filtered and unfiltered samples for all metal analyses, except ROM collects filtered samples only	Aluminum Iron Antimony Magnesium Barium Manganese Beryllium Nickel Cadmium Potassium Calcium Silver Chromium Sodium Cobalt Vanadium Copper Zinc	Aluminum Iron Antimony Magnesium Barium Manganese Beryllium Nickel Cadmium Potassium Calcium Silver Chromium Sodium Cobalt Vanadium Copper Zinc	
Metals: Other (Chromium, hexavalent: SW-846 7196A; ; Laboratory Specific Uranium Method)	Uranium		Chromium, hexavalent Uranium
Anions by IC (EPA/600/R-93/100, 300.0)	Chloride Fluoride Nitrate Sulfate	Chloride Fluoride Nitrate Sulfate	Nitrate
Radionuclide screening: (Laboratory Specific Methods)	Activity scan[4]	Gross alpha Gross beta Activity scan[4]	
Specific radionuclides: (Laboratory Specific Methods)	Technetium-99	Tritium	Strontium-89/90 Technetium-99 Tritium
Miscellaneous parameters: (Standard Methods 2320; EPA/600/4-79/020, 310.1 & 310.2)	Alkalinity		
Field parameters:	pH Specific conductance Temperature Turbidity	pH Specific conductance Temperature Turbidity	pH Specific conductance Temperature Turbidity

Footnotes (References):

1. Code #1 is based on 183-H compliance groundwater monitoring plan (Hartman and Chou, 1995); constituents in bold are dangerous waste constituents used for evaluations under WAC-173-303-645(10).
2. Code #2 is based on Tri-Party Agreement Change Control Form #107, November 1996
3. Code #3 is from IRM Monitoring Plan (DOE-RL 1997)
4. Selected wells only

Abbreviations: ICP = inductively coupled plasma; IC = ion chromatography

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1 **Table 3.3. CERCLA Interim Remedial Measure Groundwater Well Network:**

Well Number	Intended Use	Operations Period-- July 1997 to end of IRM:			
		Hourly Water Levels[1]	Steel Tape Measure[2]	Hexavalent Chromium[3]	Co-contaminants[4]
199-H3-2A	Extraction well	Transducer	Monthly	Quarterly	Semiannual
199-H4-8	Extraction well	Transducer	Monthly	Quarterly	Semiannual
199-H4-11	Extraction well	Transducer	Monthly	Quarterly	Semiannual
199-H4-12A	Extraction well	Transducer	Monthly	Quarterly	Semiannual
199-H4-15A	Extraction well	Transducer	Monthly	Quarterly	Semiannual
199-H3-4	Injection well	Transducer	Monthly		
199-H3-5	Injection well	Transducer	Monthly		
199-H4-3	Performance monitoring		Quarterly	Semiannual	
199-H4-6	Performance monitoring		Quarterly	Semiannual	
199-H4-8	Performance monitoring	Transducer	Monthly	Semiannual	
199-H4-10	Performance monitoring	Transducer	Monthly	Semiannual	
199-H4-12B	Performance monitoring	Transducer	Monthly	Semiannual	
199-H4-12C	Performance monitoring		Quarterly	Semiannual	
199-H4-13	Performance monitoring		Quarterly	Semiannual	
199-H4-14	Performance monitoring		Quarterly	Semiannual	
199-H4-15B	Performance monitoring	Transducer	Monthly	Semiannual	
199-H4-15CS	Performance monitoring		Quarterly	Semiannual	
199-H4-16	Performance monitoring		Quarterly	Semiannual	
199-H4-17	Performance monitoring		Quarterly	Semiannual	
199-H4-18	Performance monitoring		Quarterly	Semiannual	
199-H4-45	Performance monitoring		Quarterly	Semiannual	
199-H4-46	Performance monitoring		Quarterly	Semiannual	
199-H4-48	Performance monitoring		Quarterly	Semiannual	
199-H4-49	Performance monitoring		Quarterly	Semiannual	
199-H5-1A	Performance monitoring		Quarterly	Semiannual	
199-H4-4	Compliance monitoring	Transducer	Monthly	Monthly	Annual
199-H4-5	Compliance monitoring	Transducer	Monthly	Monthly	Annual
199-H4-63	Compliance monitoring	Transducer	Monthly	Monthly	Annual
199-H4-64	Compliance monitoring	Transducer	Monthly	Monthly	Annual

Footnotes:
[1] Hourly measurements using pressure transducers and data loggers
[2] Routine steel tape measurements; monthly measurements to calibrate pressure transducers
[3] Hexavalent chromium using Hach methodology, ERC Mobile Laboratory
[4] Co-contaminants: Nitrate, strontium-90, technetium-99, tritium, and uranium
[3 & 4] Field measurements for pH, specific conductance, temperature, and turbidity during all sampling
Source: DOE-RL 1997

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DOE/RL-2015-28
Revision 0

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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
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Executive Summary

This document presents a revision to the 1997 183-H Solar Evaporation Basins groundwater monitoring plan.[1] This revised monitoring plan is based on the requirements for final status facilities, as identified in the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*[2] (hereafter referred to as the Hanford Facility RCRA Permit), Part II, Condition II.F, which specifies that final status groundwater monitoring programs are subject to the requirements in WAC 173-303-645.[3] Due to the age of the plan, the U.S. Department of Energy, Richland Operations Office is revising this groundwater monitoring plan to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the post-closure unit group (e.g., changes in the constituents to be monitored, sampling frequency, well network, concentration limits, statistical evaluation, identification of point of compliance wells, and clarification of compliance period). This document will supersede the previous groundwater monitoring plan (PNNL-11573) upon modification of the Hanford Facility RCRA Permit. This corrective action groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at 183-H Solar Evaporation Basins.

The 183-H Solar Evaporation Basins are a final status, post-closure unit group (Post Closure Unit Group 2) in the 100-HR-1 Source Operable Unit (OU). The 183-H Solar Evaporation Basins are located north of the 105-H Reactor. The 183-H Solar Evaporation Basins are in modified closure with corrective action. The four basins were originally part of the 183-H water treatment facility but were used for evaporation of 300 Area fuel fabrication wastes from 1973 to 1985. In 1996, the basins were demolished and the soil was removed to a depth of 0.6 m (2 ft) below the basin floor, with excavation to 4.6 m (15 ft) below Basin 1. The basin floor depth ranged from 4.7 to 5.0 m

[1] PNNL-11573, 1997, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1659822.

[2] WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste,* Revision 8c, as amended, Washington State Department of Ecology, Richland, Washington. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/index.html.

[3] WAC 173-303-645, "Releases from Regulated Units," *Washington Administrative Code*, Olympia, Washington. Available at: http://app.leg.wa.gov/WAC/default.aspx?cite=173-303-645.

(15.5 to 16.5 ft). Groundwater protection was demonstrated through modeling and a modified closure (soil column) was approved in 1997. Clean closure was not approved due to high levels of fluoride and nitrate remaining in the soil 4.6 m (15 ft) below the Basin 1 floor. Groundwater at the site is approximately 13 m (42 ft) below ground surface.

A final status groundwater compliance monitoring program in accordance with WAC 173-303-645 was implemented in 1995 (WHC-SD-EN-AP-180[4]). The plan identified chromium (collected as a filtered sample) and nitrate as dangerous waste constituents and technetium-99 and uranium as waste indicators. Fluoride was monitored as an indicator of 183-H contamination in groundwater. Additional constituents to aid data interpretation (alkalinity, anions, and selected metals) and field parameters (pH, specific conductance, temperature, and turbidity) were also included.

The first samples collected under the compliance monitoring plan exceeded concentration limits for nitrate, chromium, uranium, and technetium-99. As a result, corrective action was required. Groundwater remediation (pump and treat) was undertaken as part of the interim remedial measure (IRM) and, therefore, the corrective action for the 183-H Solar Evaporation Basins was deferred to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)[5] program (Soper, 1997[6]). The IRM commenced in 1997 and is ongoing at the 100-HR-3 groundwater OU. In accordance with WAC 173-303-645(11), a final status, corrective action groundwater monitoring plan (PNNL-11573) replaced the compliance monitoring plan (WHC-SD-EN-AP-180) in 1997.

This revised groundwater monitoring plan retains total chromium, collected as a filtered sample, and nitrate as dangerous waste constituents identified for corrective action monitoring. Other constituents identified for monitoring in the previous plan (PNNL-11573), uranium, technetium-99, and fluoride, are removed in this revised plan.

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[4] WHC-SD-EN-AP-180, 1995, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196050052.

[5] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

[6] Soper, W.W., 1997, "Re: Acceptance of "Closure Certification for the 183-H Solar Evaporation Basins (T-1-4), 96-EAP-246" (letter to J. Wagoner, U.S. Department of Energy, Richland Operations Office, Richland, Washington from W.W. Soper), Washington State Department of Ecology, Richland, Washington, May 13. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080812H.

Fluoride is no longer monitored because it is below background and has been below its background groundwater concentration in the monitoring well network throughout the corrective action monitoring period. Monitoring of uranium is conducted under the CERCLA remedial action. Technetium-99 is monitored under the *Atomic Energy Act of 1954*[7] groundwater monitoring program. Alkalinity, anions, and metals are also not included in this plan since these analytes are collected at multiple nearby wells supporting the IRM.

This revised groundwater monitoring plan presents an updated corrective action monitoring plan of the uppermost aquifer beneath the 183-H Solar Evaporation Basins. This plan addresses the following:

- Number, locations, and depths of wells in the 183-H Solar Evaporation Basins groundwater monitoring network
- Sampling and analytical methods of dangerous waste required under corrective action monitoring
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at the 183-H Solar Evaporation Basins

This revised plan modifies the existing groundwater monitoring well network as identified in the previous groundwater monitoring plan (PNNL-11573). Previous monitoring network changes occurred in 2005 and 2013 and were incorporated into the Hanford Facility RCRA Permit. In 2005, well 199-H4-7 was removed from the monitoring network and replaced with 199-H4-8. In 2013, well 199-H4-84 replaced 199-H-3 when it was decommissioned.

This plan removes well 199-H4-12C, which is completed in the confined aquifer, from the monitoring network. Monitoring well 199-H4-12A is replaced with 199-H4-85, which is located closer to the 183-H Solar Evaporation Basins and is completed in the unconfined aquifer. New wells 199-H4-88 and 199-H4-89 were drilled in 2016 and are added to the monitoring network. In summary, upon Hanford Facility RCRA Permit modification, the well network will include wells 199-H4-8, 199-H4-84, 199-H4-85,

[7] *Atomic Energy Act of 1954*, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: http://epw.senate.gov/atomic54.pdf.

199-H4-88, and 199-H4-89. The monitoring network wells represent the point of compliance.

Groundwater flows generally toward the east-northeast beneath the 183-H Solar Evaporation Basins and is influenced by the ongoing IRM as well as changes in river stage.

The concentration limit for total chromium (filtered) in this plan is changed to 48 µg/L. This concentration represents the WAC 173-340-720(3)[8], "Model Toxics Control Act-Cleanup," "Groundwater Cleanup Standards," "Method B Cleanup Levels for Potable Groundwater," groundwater cleanup level for hexavalent chromium, which is the soluble and mobile form of chromium and is equivalent to total chromium as a filtered sample. The concentration limit for nitrate is the same as the previous plan at 45 mg/L, which is the drinking water standard in 40 CFR 141[9,10].

Under this plan, groundwater in the 183-H Solar Evaporation Basins monitoring wells will be sampled and analyzed semiannually for dangerous waste constituents (total chromium (filtered) and nitrate) and field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity). Water level measurements will be taken each time a sample is collected to satisfy WAC 173-303-645(8)(f).

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[8] WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

[9] 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr141_main_02.tpl.

[10] Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The drinking water standard for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for nitrate (NO_3) is 45,000 µg/L.

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Terms

AEA	*Atomic Energy Act of 1954*
amsl	above mean sea level
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
IRM	interim remedial measure
MCL	maximum contaminant level
MTCA	"Model Toxics Control Act—Cleanup" (WAC 173-340)
NAD83	*North American Datum of 1983*
NAVD88	*North American Vertical Datum of 1988*
OU	operable unit
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RUM	Ringold Formation upper mud
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UCL	upper confidence limit
WAC	*Washington Administrative Code*
WIDS	Waste Information Data System

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1 Introduction

This document presents the revised corrective action groundwater monitoring plan for the 183-H Solar Evaporation Basins and supersedes the previous plan (PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*). The U.S. Department of Energy (DOE), Richland Operations Office (RL), is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the post-closure unit group (e.g., changes in the constituents to be monitored, sampling frequency, well network, concentration limits, statistical evaluation, identification of point of compliance wells, and clarification of compliance period). The 183-H Solar Evaporation Basins are a post-closure unit group in Part VI, Unit 2, of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereafter referred to as the Hanford Facility RCRA Permit). The basins and underlying soil were remediated in 1996, and the unit was closed in 1997 under modified closure conditions in the Hanford Facility RCRA Permit with specified remedial measures under post-closure care (Soper, 1997, "Re: Acceptance of "Closure Certification for the 183-H Solar Evaporation Basins (T-1-4)," 96-EAP-246"). The Hanford Facility RCRA Permit, Part II, Condition II.F specifies final status groundwater monitoring program requirements will comply with WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units." Groundwater is monitored in accordance with WAC 173-303-645 and Part VI, Chapter 2, of the Hanford Facility RCRA Permit.

This plan monitors dangerous waste and field parameters in groundwater samples that are used to demonstrate the effectiveness of the associated corrective action. For regulatory purposes, the boundary of the 183-H Solar Evaporation Basins unit group is identified on the current Hanford Facility RCRA Permit Part A Form.

The 183-H Solar Evaporation Basins (waste sites 116-H-6 and 100-H-33) are located within the 100-H Area, in the 100-HR-1 Source OU (Figure 1-1). The basins (Figure 1-2) were originally part of the 183-H water treatment facility. Operating records indicate that four of the basins were used from 1973 to 1985 to evaporate various liquid waste streams, including neutralized, spent acid etch solutions from the 300 Area Fuel Fabrication Facility containing technetium-99 and uranium, as well as miscellaneous used and unused chemicals (DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*). All operations ceased in 1985 and Basin 1 solids and sludge material was removed in 1985. In 1990, Basins 1 and 4 were cleaned by wet sandblasting. Waste generated during sandblasting was packaged and disposed.

In 1989 and 1991, the basin concrete and soil were sampled. Analytical results indicated the presence of contamination within 0.6 m (2 ft) below the bottom of the basin structure (DOE/RL-97-48, Section 1.2.4). Decontamination and demolition of the basins started in September 1995, and the demolition waste was removed and disposed (DOE/RL-97-48, Section 1.2.4). As a result of the 1991 borehole data showing contamination, the soil underlying the basins was removed starting in 1996 with excavation to a depth of 0.6 m (2 ft) below the structure (DOE/RL-97-48, Section 1.2.4). Deeper contamination was indicated below Basin 1 and soil removal continued to 4.6 m (15 ft) below the former structure (DOE/RL-97-48, Section 1.2.4). A test pit below Basin 1 was dug to 7.6 m (25 ft) (DOE/RL-97-48, Section 1.2.4). DOE/RL-97-48 does not specify whether the Basin 1 test pit depth is measured from ground surface or from the excavation depth, however, the test pit results represent soil at least 7.6 m (25 ft) bgs. Both nitrate and fluoride contamination were identified at this depth (DOE/RL-97-48, Section 1.2.4). No additional soil removal was performed (DOE/RL-97-48, Section 1.2.4).

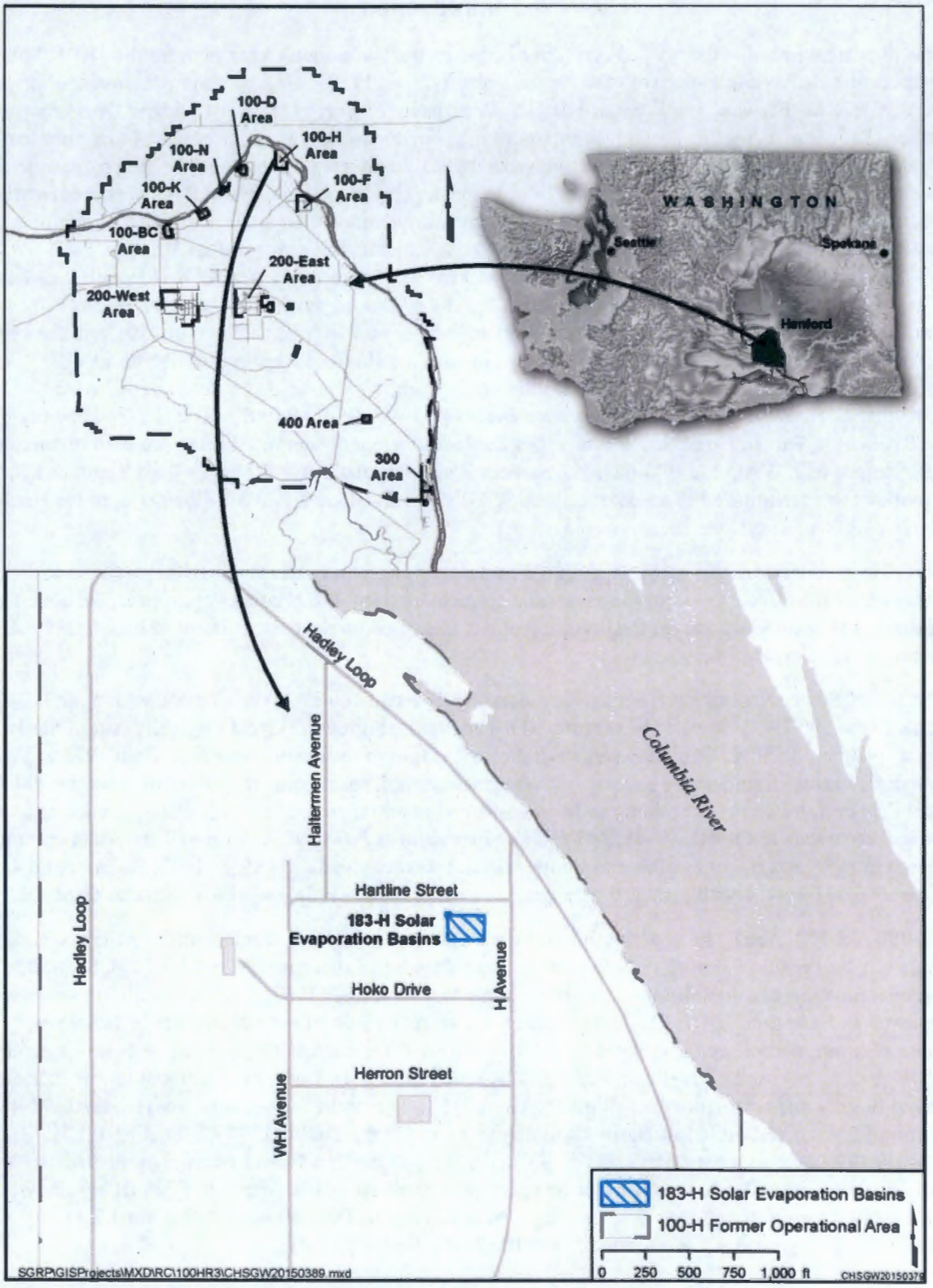
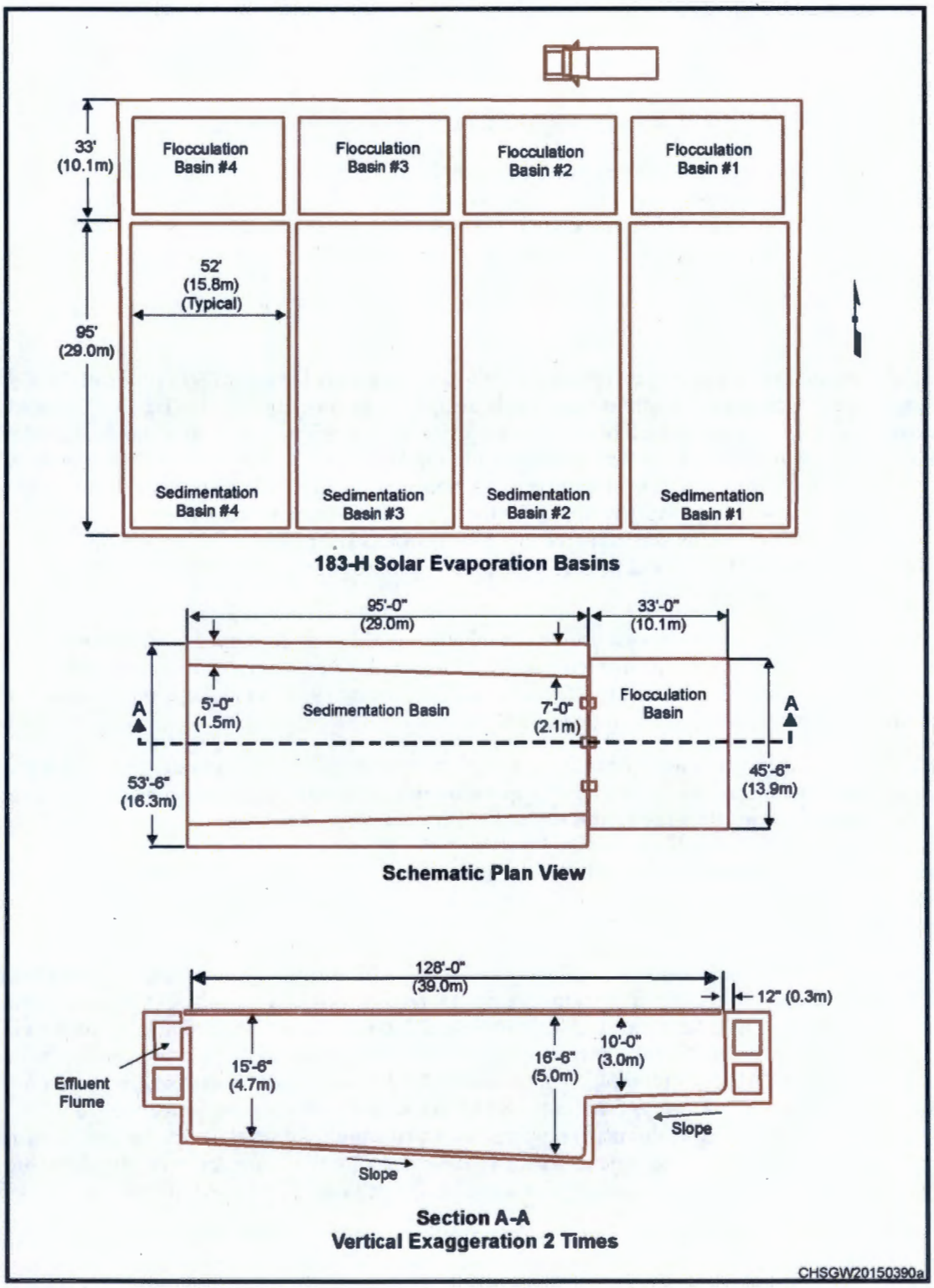


Figure 1-1. Location Map for 183-H Solar Evaporation Basins



Source: DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*

Figure 1-2. Schematic (Plan and Section Views) of the Former 183-H Solar Evaporation Basins

Because of the presence of contamination extending from 4.6 to 7.6 m (15 to 25 ft) below the Basin 1 structure, waste site 116-H-6 underwent a modified closure in accordance with the Hanford Facility RCRA Permit in 1997, which included groundwater monitoring. The radiological component of the basins was later addressed under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as the 100-H-33 waste site and reclassified to (interim) No Action.

RCRA compliance groundwater monitoring began at the 183-H Solar Evaporation Basins in 1985, based on the groundwater monitoring requirements for interim status facilities. In 1994, the Washington State Department of Ecology (Ecology) issued the Hanford Facility RCRA Permit, which included the Part II, Condition II.F requirement that final status treatment, storage, and disposal (TSD) units comply with WAC 173-303-645. A final status compliance monitoring plan under WAC 173-303-645 (WHC-SD-EN-AP-180, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*) was initiated in 1995.

Results from the first final status compliance monitoring samples collected in 1995 (Furman, 1996, "Exceedance of Concentration Limits in Groundwater at 183-H Solar Evaporation Basins") showed exceedances of the concentration limits for nitrate, chromium, uranium, and technetium-99 that were established per WAC 173-303-645(5). The regulations in WAC 173-303-645(11), "Corrective Action Program," require implementation of a corrective action program to reduce contaminant concentrations in groundwater. Groundwater corrective action for the 183-H Solar Evaporation Basins was implemented through the CERCLA interim action for the 100-HR-3 Groundwater OU, which includes groundwater affected by the basins. The CERCLA interim remedial measure (IRM) at the 100-HR-3 OU consists of two pump and treat systems.

A corrective action groundwater monitoring plan (PNNL-11573) was developed in accordance with WAC 173-303-645(11) and implemented in 1997. The post-closure plan (DOE/RL-97-48) was incorporated into the Hanford Facility RCRA Permit in February 1998 and includes the corrective action groundwater monitoring described in PNNL-11573.

The purpose of this groundwater monitoring plan is to present an updated groundwater monitoring program for dangerous wastes from the 183-H Solar Evaporation Basins. Specifically, this plan is intended to satisfy monitoring requirements for a final status unit undergoing corrective action, as prescribed in Part VI of the Hanford Facility RCRA Permit and required by WAC 173-303-645(11). This monitoring plan is the principal controlling document for conducting groundwater monitoring at the 183-H Solar Evaporation Basins and is used to modify the Hanford Facility RCRA Permit. Once the permit is modified, this document will supersede PNNL-11573.

This revised plan monitors dangerous wastes (total chromium [filtered] and nitrate) and includes field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity). Other constituents monitored in PNNL-11573 (uranium, technetium-99, and fluoride) are not included in this plan. Uranium is monitored under the 100-HR-3 OU pump and treat system, technetium-99 is monitored under the *Atomic Energy Act of 1954* (AEA) monitoring program (DOE/RL-2015-56, *Hanford Atomic Energy Act Sitewide Groundwater Monitoring Plan*), and fluoride will no longer be monitored. The corrective action monitoring program detailed in this plan requires semiannual sampling of total chromium (collected as a filtered sample), nitrate, and field parameters at five wells. Additionally, water level measurements are also required each time that a sample is collected in accordance with WAC 173-303-645(8)(f).

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the unit and incorporates knowledge regarding contamination originating from 183-H Solar Evaporation Basins and includes the following chapters and appendices:

- Chapter 2 summarizes background information and references other documents that contain more detailed or additional information. It also describes 183-H Solar Evaporation Basins and the regulatory basis, types of waste present, and the pertinent geology and hydrogeology beneath 183-H Solar Evaporation Basins; and it presents a brief history of groundwater monitoring. This information is summarized as a CSM to aid in development of the groundwater monitoring program.
- Chapter 3 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols.
- Chapter 4 describes data evaluation and reporting.
- Chapter 5 contains the references cited in this plan.
- Appendix A provides the quality assurance project plan (QAPjP).
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring.
- Appendix D presents monitoring data of the dangerous wastes (including hexavalent chromium results) that have been collected from the network wells during corrective action monitoring.

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2 Background

This chapter describes 183-H Solar Evaporation Basins and their operating history, regulatory basis, waste and waste characteristics associated with 183-H Solar Evaporation Basins, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for 183-H Solar Evaporation Basins.

The information contained in this chapter was obtained from several sources, including previous groundwater monitoring plans listed in Section 2.5 and the following documents:

- DOE/RL-88-04, Rev. 3, *Interim Status Closure/Post-Closure Plan 183-H Solar Evaporation Basins*
- DOE/RL-97-48, *183-H Solar Evaporation Basins Postclosure Plan*
- DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*
- DOE/RL-2011-111, *Proposed Plan for Remediation of the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*

2.1 Facility Description and Operational History

The 183-H Solar Evaporation Basins were located beside the Columbia River in the northern portion of the Hanford Site (Figure 2-1). Each basin was 16 m (52 ft) wide and 39 m (128 ft) long and contained a 5 m (16 ft) deep sedimentation basin and a smaller, 3 m (10 ft) deep flocculation basin. The basins were surrounded by earthen berms.

The concrete basins were originally part of the 183-H water treatment plant for treating cooling water and operated concurrently with the 100-H Reactor from October 1949 to April 1965. At that time, there were 16 basins. Demolition of the 183-H water treatment plant was initiated in the spring of 1974. The 183-H head house, 12 of the flocculation and sedimentation basins, filter building, and the clearwell pump room were demolished and the underground portions were backfilled to grade (BHI-00127, *100-H Area Technical Baseline Report*, Section 4.6). Four basins were retained for use as solar evaporation basins for chemical waste from the 300 Area (PNL-6470, *Revised Ground-Water Monitoring Compliance Plan for the 183-H Solar Evaporation Basins*), as well as for miscellaneous used and unused chemicals. These remaining basins were modified to seal openings and to install a pipeline before being used to evaporate various liquid waste streams, including neutralized, spent acid etch solutions containing technetium-99 and uranium from the 300 Area Fuel Fabrication Facility (DOE/RL-88-04, Rev. 3, Section 1.A-3).

Use of the 183-H Solar Evaporation Basins for liquid disposal began in June 1973, when liquid was first pumped into Basin 1, but discharges ceased after two months due to operational problems at the 300 Area. Discharge to the basins resumed in 1975 and continued until 1978, when nitrate contamination in a downgradient well (199-H4-3) was attributed to wastes from the unlined Basin 1. Basins 2 and 3, with sprayed-on liners of a polyurethane material, were used beginning in 1977 and 1978, and Basin 1 was permanently retired. Basin 4, with a sprayed-on butyl and Hypalon® liner, also was used beginning in October 1982. Basins 2, 3, and 4 were used until 1985. The total volume of routine wastes from the fuel fabrication process discharged to the 183-H Solar Evaporation Basins from 1973 to 1985 was 9.573 million L (2.529 million gal) (PNL-6470).

® Hypalon is the registered trademark for a series of chlorosulfonated polyethylene synthetic rubbers manufactured by DuPont Dow Elastomers, Wilmington, Delaware.

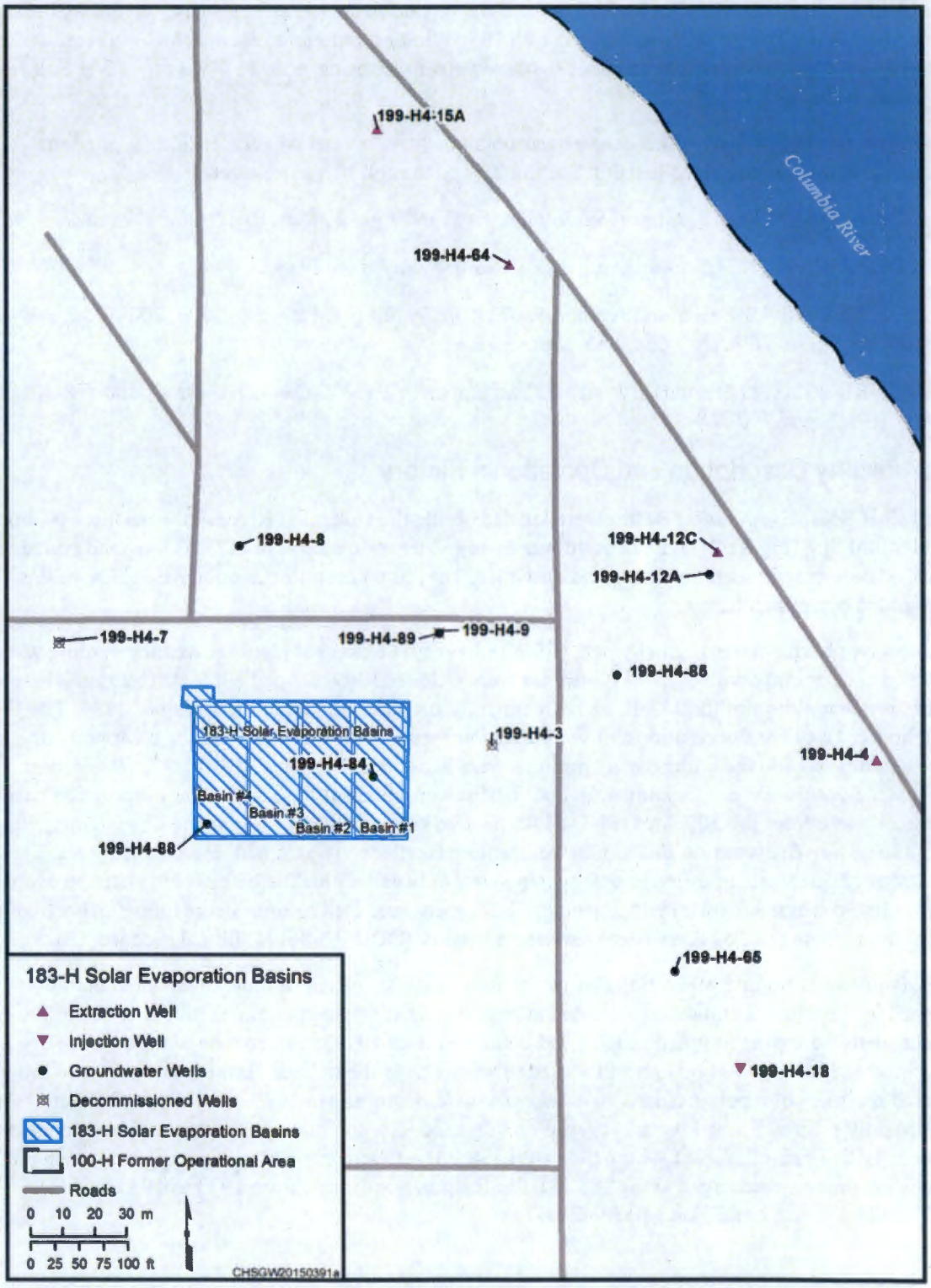


Figure 2-1. Map of 183-H Solar Evaporation Basins

Basin 1 solids and sludge were removed in 1985. Basins 2, 3, and 4 held waste consisting of three distinct layers: a basal crystalline layer, a sludge layer, and a liquid layer on top. In 1986, the liquid waste was solidified inside lined drums. The sludge and crystalline layers were removed from the basins by manually shoveling and/or scooping the material into the drums. Basins 1 and 4 were subsequently cleaned by wet sandblasting. By the end of 1990, all waste had been removed.

The basins were decontaminated and demolished in 1996 and soil was removed to at least 0.6 m (2 ft) beneath each of the former basins. Below Basin 1, additional soil was removed up to a depth of 4.6 m (15 ft) below the former structure (DOE/RL-97-48). In Basin 1, a test pit was excavated to a depth of at least 7.6 m (25 ft) bgs (DOE/RL-97-48, Section 1.2.4). Soil from the test pit was sampled and both nitrate and fluoride contamination above 1996 WAC 173-340, "Model Toxics Control Act—Cleanup" (MTCA) Method B cleanup levels were detected at this depth. No further source remediation was done and the excavation was filled with clean soil to meet the surrounding grade. All decontamination and demolition waste and contaminated soil was transported from the site and appropriately disposed.

2.2 Regulatory Basis

In 1986, DOE entered into a regulatory order (EPA and Ecology, 1986, EPA Regulatory Order No. 1085-10-07-3008 and Ecology No. DE 86-133). The compliance order mandated interim status groundwater quality assessment monitoring according to 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," and WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," at the 183-H Solar Evaporation Basins. This initiated the RCRA groundwater monitoring program at the 183-H Solar Evaporation Basins (PNL-6470).

In May 1987, DOE issued a final rule (10 CFR 962, "Byproduct Material"), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. The hazardous waste components of mixed waste were determined to be subject to Ecology authority to regulate these waste since August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes 183-H Solar Evaporation Basins.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include source, special nuclear, and byproduct materials as defined in the AEA. AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the state of Washington under RCRA or RCW 70.105.

In 1994, Ecology issued the Hanford Facility RCRA Permit. The 183-H Solar Evaporation Basins were included as a closure unit in Part V of the permit, which contains requirements specifically applicable to TSD units that are undergoing closure. Part II, Condition II.F of the permit specified that a groundwater monitoring program under final status was subject to the requirements of WAC 173-303-645. A final status compliance monitoring program was prepared in 1995 (WHC-SD-EN-AP-180) to comply with the groundwater monitoring requirements specified in Part II, Condition II.F., of the permit and in the requirements established in Chapter 3.0 of Part VI, Post-Closure Unit 2.

The first sample set collected under the final status plan (in Fall 1995 with confirmation samples collected in Spring 1996) showed that downgradient concentrations of the four identified analytes (nitrate, chromium, uranium, and technetium-99) exceeded the concentration limits established in the compliance monitoring plan (WHC-SD-EN-AP-180) (Furman, 1996). WAC 173-303-645(11) requires corrective action activities to reduce contaminant concentrations in groundwater.

Groundwater protection at the site was demonstrated through modeling and a modified closure (soil) was approved by Ecology on May 13, 1997 (Soper, 1997). The site was not clean-closed under RCRA because fluoride and nitrate concentrations were identified above the 1996 MTCA (WAC 173-340) Method B cleanup levels. Therefore, the unit was closed in place under the modified closure provisions of the Hanford Facility RCRA Permit with post-closure care. Corrective action for the contaminated groundwater attributable to the basins was coordinated with remedial action for the 100-HR-3 OU under CERCLA (Soper 1997). Remedial action under CERCLA to address chromium groundwater contamination in the 100-H Area was initiated as part of CERCLA remediation activities through a pump and treat system. The IRM to remove hexavalent chromium began operation in 1997 as specified in DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. Although nitrate was not specifically targeted by the CERCLA IRM, it was considered likely that nitrate would be retained on the ion exchange columns utilized by the pump and treat system (DOE/RL-97-48). The CERCLA IRM is ongoing and is not subject to the conditions of the Hanford Facility RCRA Permit.

Corrective action groundwater monitoring at the 183-H Solar Evaporation Basins was initiated in accordance with WAC 173-303-645(11). In 1997, the corrective action groundwater monitoring plan (PNNL-11573) replaced the compliance monitoring plan (WHC-SD-EN-AP-180) and was incorporated in the post-closure plan (DOE/RL-97-48) and the Hanford Facility RCRA Permit. Corrective action groundwater monitoring under PNNL-11573 continues to this day.

RCRA closures do not have authority to address the cleanup of radiological contamination, which is performed under CERCLA. Waste site 116-H-6 pertains to the chemical contamination beneath the site which underwent a modified closure under the Hanford Facility RCRA Permit (Soper, 1997). Accordingly, the 116-H-6 waste site was reclassified to Closed Out in 1997 in the Waste Information Data System (WIDS). A second waste site for the 183-H Solar Evaporation Basins, 100-H-33, was created to address the radiological contamination that is within the same footprint as 116-H-6. Waste site 100-H-33 (radiological component) was evaluated and reclassified in 2012 to No Action in WIDS.

2.3 Waste Characteristics

The waste discharged to the 183-H Solar Evaporation Basins from 1973 to 1985 was received from the 300 Area Fuel Fabrication Facility, along with miscellaneous used and unused chemicals. The four basins received routine waste consisting of spent acid etch solutions (i.e., chromic, hydrofluoric, nitric, and sulfuric acids), typically neutralized with sodium hydroxide (PNNL-11573). Metal constituents included aluminum, chromium, copper, manganese, nickel, silicon, uranium, and zirconium (primarily in the form of precipitates after neutralization). The resultant slurry of liquid and metal precipitates was discharged into the basins.

Chemical analyses were not performed routinely on the waste discharged during the operating life of the basins; however, chemical waste disposal permits indicate that some of the waste was corrosive (high and low pH). PNNL-11573 reported up to 700 μg/L of chromium were found in a monthly composite sample.

The neutralized waste contained high concentrations of nitrate and copper from the nitric acid used in the copper-stripping procedures. Chromium waste included hexavalent chromium, mostly from the chromic acid used in fuel fabrication. After 1983, hexavalent chromium was reduced to its trivalent state before disposal (PNL-6728, *Geohydrologic Characterization of the Area Surrounding the 183-H Solar Evaporation Basins*, Section 2.4). Two other minor sources of chromium were the etching of stainless steel (mostly trivalent chromium) and the disposal of various industrial solutions.

The routine waste included uranium and technetium-99, causing the material to be categorized as nontransuranic, low-level, radioactive waste. Nonroutine waste discharged to the basins periodically included unused chemicals and spent solutions from miscellaneous processes, development tests, and laboratories. These discharges included the following components: cadmium and cadmium compounds; copper and copper compounds; oxalic acid; cyanide, mercury, and lead compounds; barium perchlorate; hydrazine; chromium and chromium compounds; vanadium pentoxide; and nickel and nickel compounds.

Operation of the 183-H Solar Evaporation Basins ceased in 1985. From 1985 to 1988, the 300 Area neutralized waste acid underwent solids separation in the 313 Building by use of a filter and a centrifuge. The solids were contained in the building for later disposal in the 200 Area. The liquid was sent to the 311 Tank Farm for storage; however, the effluent was taken to the 340-B Facility by tanker truck and eventually sent by rail car to the 200 Area Double-Shell Tank system for long-term storage (DOE/RL-2010-99, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*, Section 1.3.1).

2.4 Geology and Hydrogeology

The following documents describe the geology and hydrogeology of the 100-H Area and 100-HR-3 groundwater OU, including the region of 183-H Solar Evaporation Basins, in detail:

- DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*
- PNL-6728, *Geohydrologic Characterization of the Area Surrounding the 183-H Solar Evaporation Basins*
- BHI-00917, *Conceptual Site Models for Groundwater Contamination at 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units*
- WHC-SD-EN-TI-011, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*
- WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*

2.4.1 Stratigraphy

The 100-H Area is underlain by unconsolidated sediments and the Columbia River Basalt Group. Unconsolidated sediments in this area include the Hanford formation (informal name) and the Ringold Formation. The stratigraphy of the 100-H Area has been described in WHC-SD-EN-TI-132 and DOE/RL-2010-95. Stratigraphic units at 100-HR-3 are listed in the following text and shown on the left side of Figure 2-2.

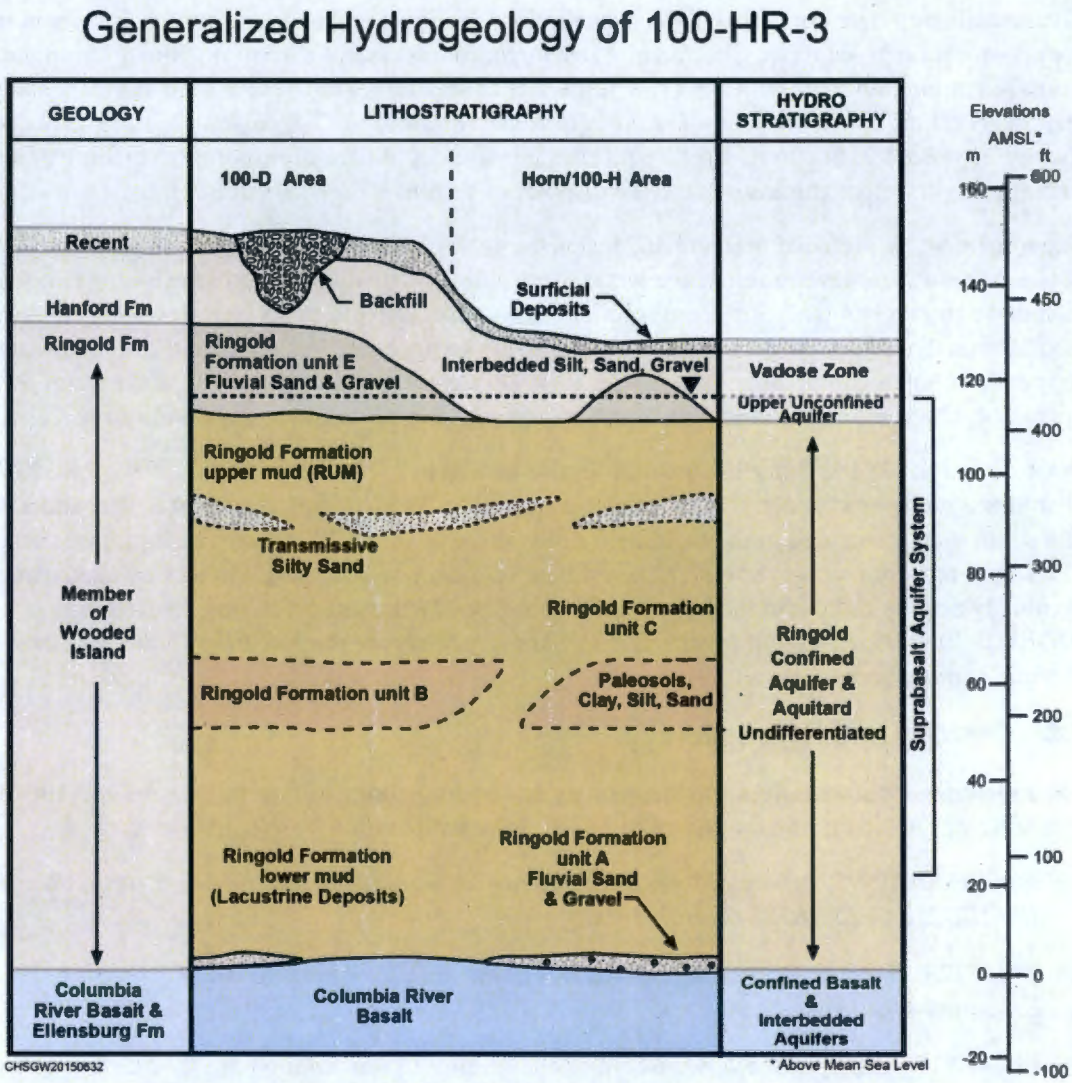


Figure 2-2. Stratigraphy and Hydrogeologic Units of 100-HR-3

Surface sediments at the 100-H Area include Holocene deposits and backfill, generally less than 0.3 m (1 ft) thick. Recent deposits include eolian sands and river alluvium, which were placed over the past 10,000 years, and backfill materials deposited by humans. Construction backfill varies in depth, depending on the excavated depth of waste sites and building foundations, and backfill material may cover larger graded areas to depths of 0.3 m (1 ft) or more. Backfill deposits may be up to 8 m (26 ft) thick near the 100-H reactor and 183-H Clearwells, but are generally less than 5 m (16 ft) thick in other areas.

The Hanford formation consists predominantly of unconsolidated sediments that cover a wide range of grain sizes, from boulder-sized gravel to sand, silty sand, and silt. The Hanford formation facies consists of moderately to very poorly sorted, large to very large, cobble- to boulder-sized clasts in open framework gravels that include discrete sand lenses, with little or no silt and clay-sized material. The Hanford formation has traditionally been classified into three separate lithofacies: gravel-dominated, sand-dominated, and interbedded sand and silt-dominated (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*).

The gravel-dominated Hanford formation is highly basaltic, ranging from approximately 50 to 80 percent basalt (WHC-SD-EN-TI-011). The sand fractions are also high in basalt content, with the remaining portion composed of feldspar, quartz, and traces of mica. The grains typically are subround to round gravel and subangular to subround in the sand grain fraction. The gravel-dominated facies typically are well stratified and contain little to no cementation (WHC-SD-EN-TI-132). Discrete sand lenses are present in 100-D/H, which may serve as preferential flow paths or collection zones for vadose zone contaminants. Caliche (calcium carbonate crust) is occasionally observed on Hanford formation gravels. The thickness of the Hanford formation ranges from 10 to 19 m (33 to 62 ft) across the 100-H Area and makes up most of the unconfined aquifer material.

Ringold Formation underlies the Hanford formation and is a combination of alluvial and lacustrine deposits produced by the ancestral Columbia River and other regional river systems. The formation is approximately 41 m (134 ft) thick beneath the 100-H Area, and consists of nonindurated and semi-indurated clay, silt, fine- to coarse-grained sand, and variably cemented, multilithic, granule to cobble gravel. The Ringold Formation under the 100-H Area includes the following three main depositional facies: overbank/paleosol deposits, sand and interbedded overbank paleosol deposits, and the lacustrine-dominated lower mud unit. Ringold Formation unit E is the uppermost Ringold unit, but is found in small areas at 100-H.

The Ringold Formation upper mud (RUM) unit is dominated by a fine-grained overbank paleosol facies association that is up to 61 m (200 ft) thick (WHC-SD-EN-TI-132). The silt- and clay-rich RUM has low hydraulic conductivity values relative to the Hanford formation. The RUM is considered an aquitard and forms the base of the unconfined aquifer. Within the RUM, thin sand-to-gravel layers form zones with variable hydraulic conductivity (K). Horizontal K ranges from 1.2×10^{-4} to 1.9×10^{-3} cm/sec (3.4×10^{-1} to 5.4 ft/day) and vertical K ranges from 1.4×10^{-8} to 5.0×10^{-3} cm/sec (4.0×10^{-5} to $1.4 \times 10^{+1}$ ft/day). These sand and gravel layers form confined or semiconfined aquifers within the RUM. The connectivity of the first water bearing unit of the RUM across the site and the extent of connection to the unconfined aquifer has not been determined. The top surface of the RUM is found between 11 and 40 m (37 and 66 ft) below ground surface (bgs) at 100-H.

The Ringold unit B separates and differentiates the fine-grained sediment of the RUM from the underlying fine-grained sediment of the Ringold lower mud unit. Fine sand to silty sand deposits of the Ringold unit B overlie the lower mud unit and are approximately 15 to 24.5 m (50 to 80 ft) thick beneath 100-D/H. The Ringold unit B sands are inferred to be equivalent to fluvial gravel deposits of unit B (and possibly unit D) to the south in the Cold Creek Syncline. Ringold units A and C, which are present in other parts of the Cold Creek Syncline to the south of Gable Mountain, have not been found beneath 100-H. The lower mud consists of fine-grained (silt- and clay-dominated) deposits that are approximately 23.0 to 30.5 m (75 to 100 ft) thick beneath 100-H (WHC-SD-EN-TI-132).

Approximately 300 basalt flows of the Columbia River Basalt Group have been identified, with a maximum total thickness of approximately 4,600 m (15,000 ft) in the Pasco Basin. The basalt has been divided into four formations from youngest to oldest: Saddle Mountains Basalt, Wanapum Basalt, Grand Ronde Basalt, and Imnaha Basalt. The Elephant Mountains Member of the Saddle Mountains Basalt Formation is the upper basalt unit beneath 100-H. The Saddle Mountains Basalt Formation was encountered in well 199-H4-15C at a depth of 95 m (314 ft). Sedimentary units of the Ellensburg Formation are interbedded with the basalt flows. The shallowest of these beneath 100-H is the Rattlesnake Ridge interbed.

Geologic cross-sections, which include selected wells in the 183-H Solar Evaporation Basins monitoring network and surrounding area, present the approximate stratigraphy underlying and adjacent to the site (Figures 2-3 and 2-4).

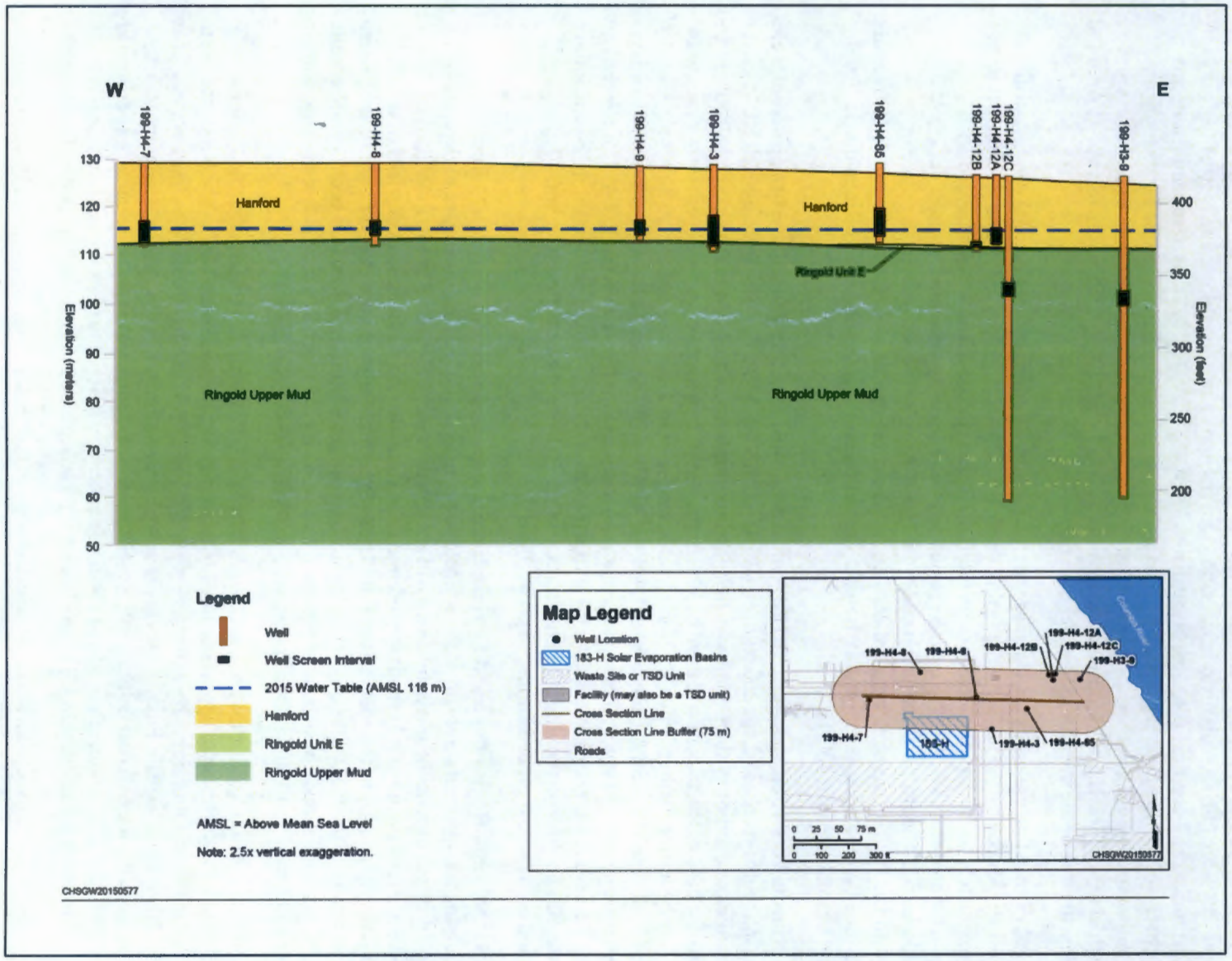


Figure 2-3. West-East Geologic Cross Section Showing the Stratigraphy Underlying the 183-H Solar Evaporation Basins

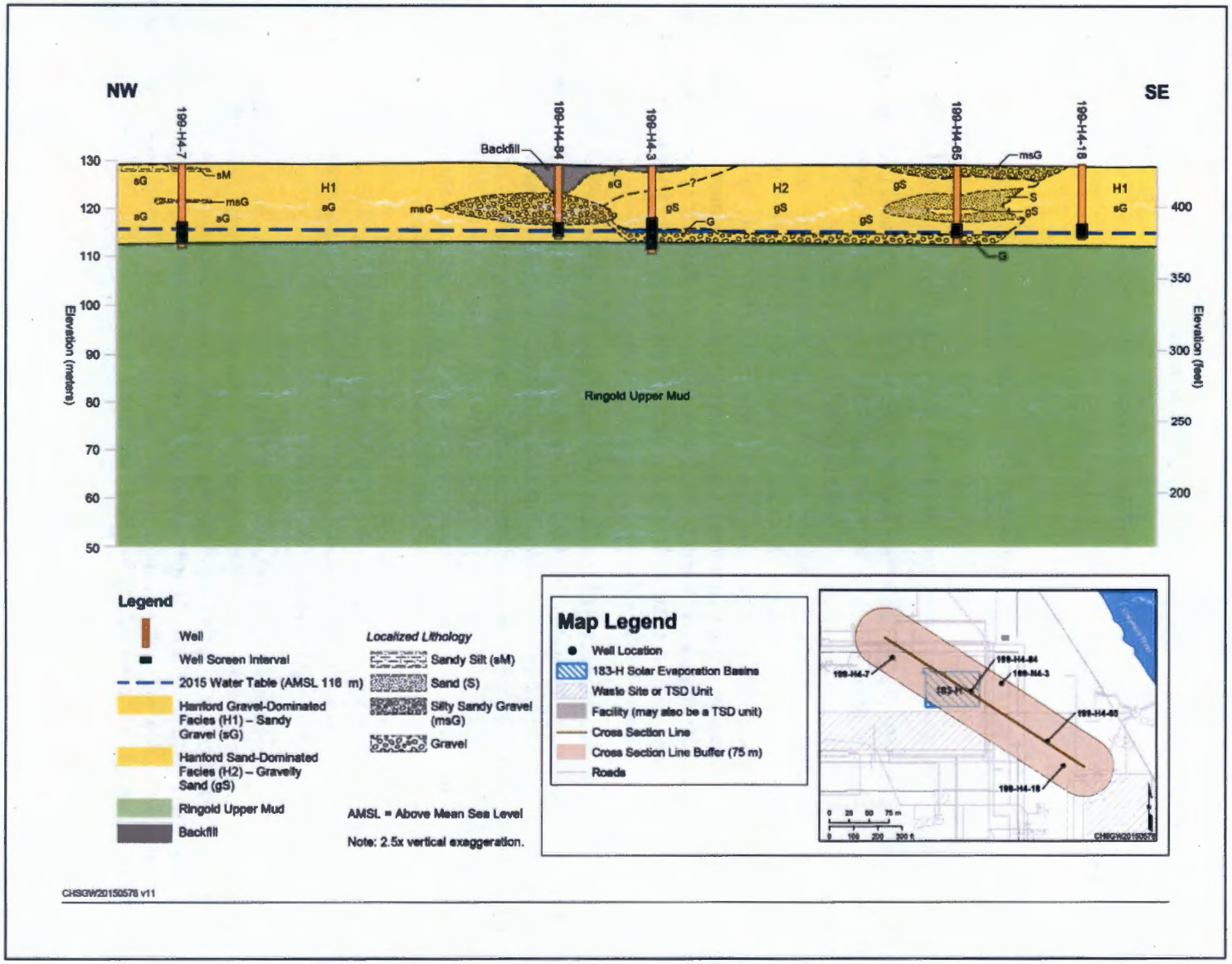


Figure 2-4. Northwest-Southeast Geologic Cross Section Showing the Stratigraphy Underlying the 183-H Solar Evaporation Basins

2.4.2 Hydrogeology

The principal hydrostratigraphic units encountered beneath the 100-H Area include the following, in descending order:

- The unsaturated sediments of the Hanford formation (vadose zone)
- An unconfined aquifer in the saturated sediments of the Hanford formation, and in some areas, within remnants of the Ringold Formation unit E
- A series of confined (or semiconfined) aquifers within the Ringold Formation
- A confined aquifer (within the Saddle Mountain Basalt Formation and the Rattlesnake Ridge interbed)

Figure 2-2 shows, on the right side, a generalized hydrostratigraphic column for the 100-H Area.

The vadose zone (unsaturated zone) extends from ground surface to the water table of the uppermost aquifer. Also called the zone of aeration, it includes the soil at the surface, the capillary fringe zone above the principal water bearing zone, the periodically rewetted zone, and the combined rock, soil, air, and moisture interface linking the water table to the vadose zone. As the water table fluctuates in response to river stage and changes in recharge rates, the periodically rewetted zone experiences either saturated or unsaturated conditions. The capillary fringe is the edge of that wetted surface where water seeps into the vadose zone material because of tension saturation. The thickness of the capillary fringe is typically small in sand and gravel formations (e.g., a centimeter or two), whereas the periodically rewetted zone in areas near the river may be as much as 2 m (6 ft) thick. The dominant stratigraphic unit in the vadose zone underlying 100-H is the Hanford formation.

The unconfined aquifer is the zone between the water table and the surface of the RUM. At 100-H, the unconfined aquifer is primarily present in the Hanford formation, since the Ringold Formation unit E is absent in most locations. The unconfined aquifer thickness at 100-HR-3 generally thins from west to east from 100-D toward 100-H. Thickness of the unconfined aquifer ranges from near 0 to 12 m (39 ft) across the area. At the 183-H Solar Evaporation Basins, the aquifer is approximately 1.5 m (5.0 ft) thick, with some seasonal variation. Aquifer thickness is greater beneath 100-D, where the unconfined aquifer matrix consists solely of Ringold Formation unit E sediments. The unconfined aquifer matrix in the 100-H Area consists of Hanford formation sediments where Ringold Formation unit E sediments are typically absent because of erosion. However, some remnants of unit E are present locally. The aquifer is also influenced by the river stage, which causes fluctuations in the water table. Areas closest to the river are most affected by these fluctuations, with the effect muted farther inland (DOE/RL-2010-95).

The upper confined aquifer occurs within the silty clayey sand to sandy silty clay unit of the Ringold Formation. As presented in Section 2.4.1, the stratigraphic units identified within the Ringold Formation in the 100-H Area include the RUM, the Ringold unit B, the lower mud, and Ringold unit A. Aquifers found below the upper surface of the RUM are typically confined or semiconfined, but leakage between the units may also occur. A basalt-confined aquifer occurs within the uppermost basalt flow of the Saddle Mountains Basalt Formation and the Rattlesnake Ridge interbed.

2.4.3 Groundwater Flow Interpretation

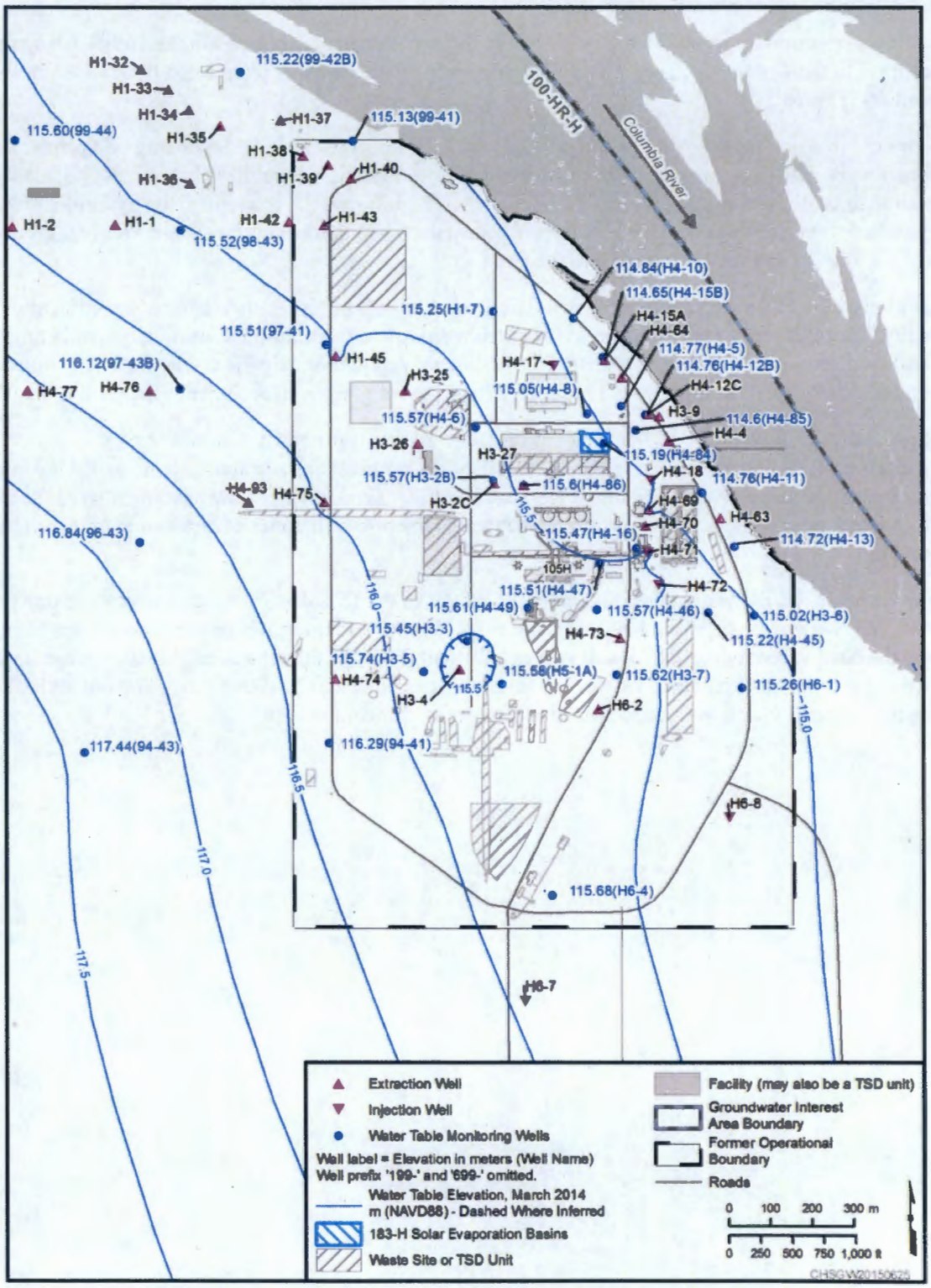
Groundwater generally flows from west to east in the uppermost aquifer beneath the 100-H Area and discharges to the Columbia River. The direction of groundwater flow is interpreted from water table elevations (Figure 2-5).

The water table is affected by daily and seasonal fluctuations in river stage, depending on upstream dam operations. Fluctuations in river stage cause hydraulic gradients in the aquifer immediately adjacent to the shoreline to be highly variable. When the river stage is high for weeks or months, the hydraulic gradient in the aquifer reverses near the river, and river water can flow into the aquifer. When the river level drops, this water flows from the bank back into the river.

Operation of the HX pump and treat system has created changes in groundwater flow direction and velocity. These changes are expressed as local depressions and mounds in the water table, affecting the local flow direction and gradient, primarily in the unconfined aquifer. However, the flow directions and gradients experienced during low and high river stage have a greater effect in wells adjacent to the river.

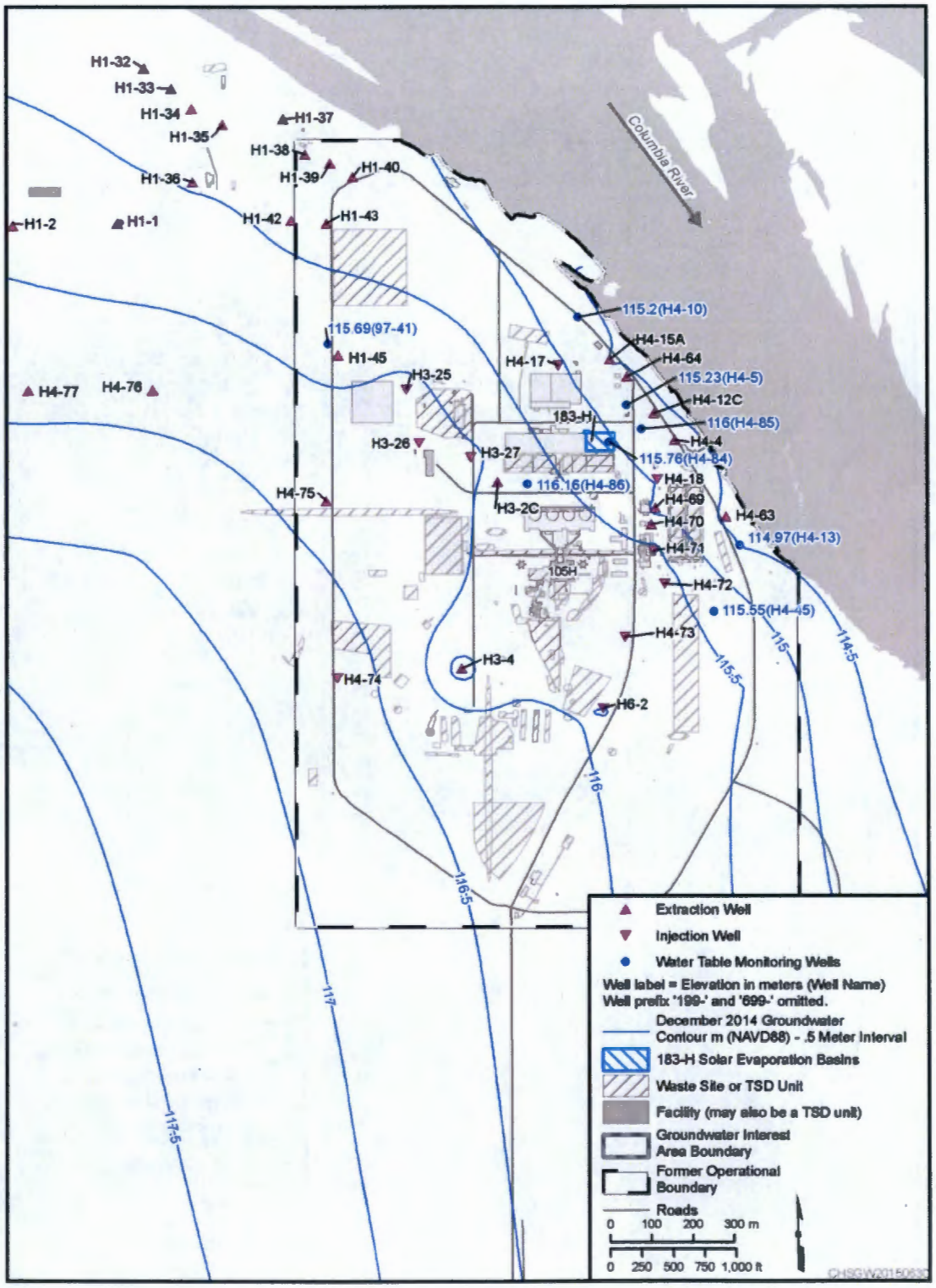
The groundwater flow at the 183-H Solar Evaporation Basins is primarily toward the river (east-northeast) during most of the year. Figures 2-6 and 2-7 present the water table maps for low and high river stage, respectively. The low river stage illustrates groundwater flow heading toward the river with isolated areas of effect from the pump and treat extraction well cones of depression or injection well mounding.

Water levels in the RUM are currently under the effects of the remediation system, which is extracting water from two locations (wells 199-H3-2C and 199-H4-12C). In areas where extraction is not taking place, the head value for the RUM well is generally slightly lower than the overlying unconfined aquifer, indicating a downward gradient. However, this is not consistent across 100-H Area, and not all RUM wells have a nearby well in the unconfined aquifer to use for comparison.



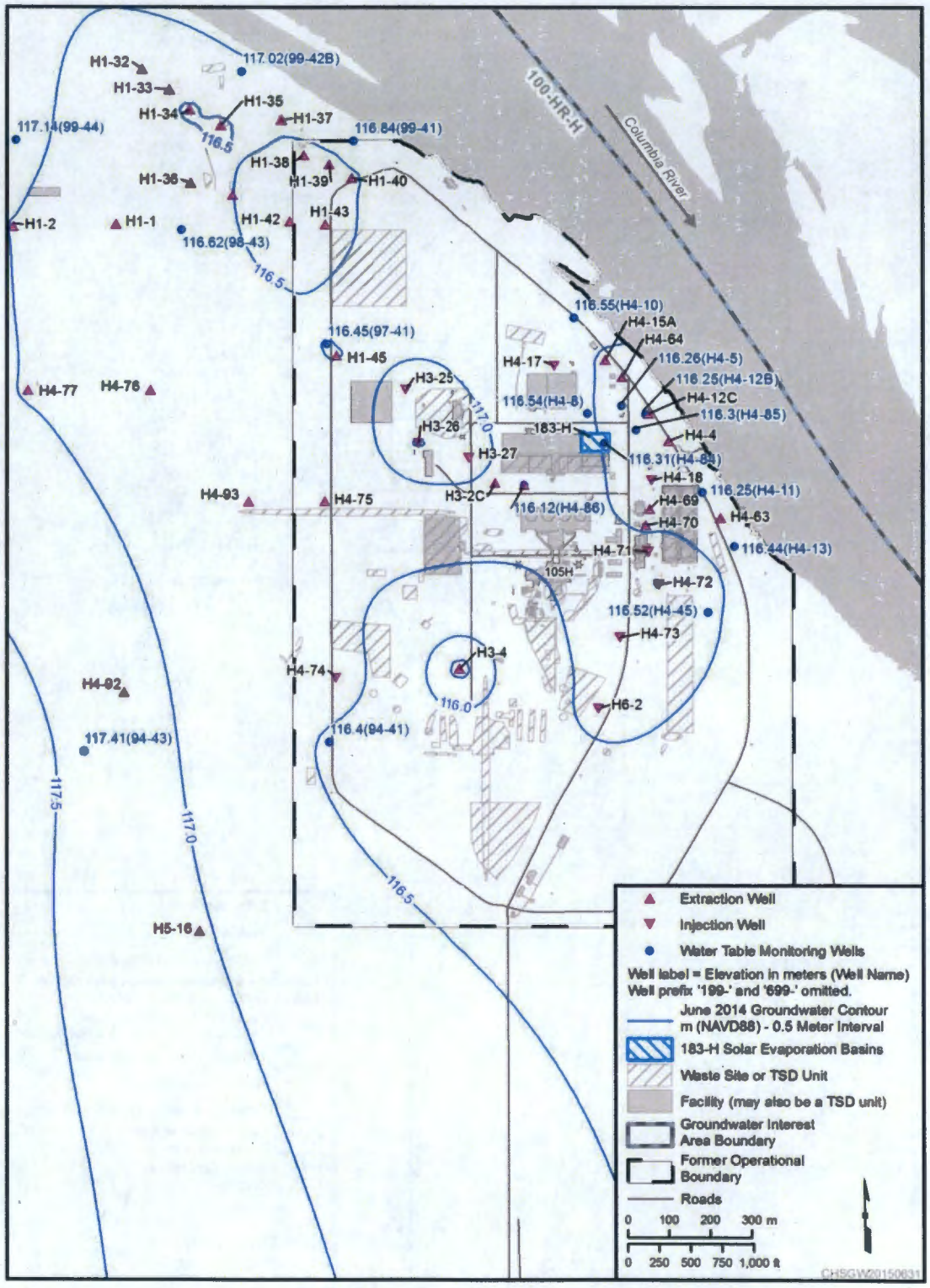
Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 2-5. Water Table Map for 100-H Area (March 2014)



Reference: NAVD88, *North American Vertical Datum of 1988*.

Figure 2-6. Water Table Contours (December 2014; Low River Stage)



Reference: NAVD88, *North American Vertical Datum of 1988.*

Figure 2-7. Water Table Contours (June 2014; High River Stage)

2.5 Summary of Previous Groundwater Monitoring

Table 2-1 lists the previous groundwater monitoring plans implemented at the 183-H Solar Evaporation Basins.

Table 2-1. Previous Monitoring Plans

Document	Date Issued	Monitoring Program
PNL-6470, *Revised Ground-Water Monitoring Compliance Plan for the 183-H Solar Evaporation Basins*	1986	Interim Status Compliance[a]
DOE/RL-88-04, Rev. 1, Rev. 2, and Rev. 3, *Interim Status Closure/Post-Closure Plan 183-H Solar Evaporation Basins*	1988, 1990, 1991	Interim Status Compliance[a]
WHC-SD-EN-AP-180, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*	1995	Final Status Compliance[b]
PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*[c]	1997	Final Status Corrective Action[d]

a. The compliance monitoring programs in PNL-6470 and DOE/RL-88-04 were developed to satisfy the requirements in 40 CFR 265.90, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Applicability," and WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards."

b. The compliance monitoring program satisfied the requirements of WAC 173-303-645(10), "Dangerous Waste Regulations," "Releases from Regulated Units," "Compliance Monitoring Program."

c. The requirements identified in PNNL-11573 were incorporated in WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste.*

d. The corrective action monitoring program satisfies the requirements of WAC 173-303-645(11), "Dangerous Waste Regulations," "Releases from Regulated Units," "Corrective Action Program."

Limited groundwater monitoring was conducted during the operational life of the 183-H Solar Evaporation Basins (1973 to 1985). Analytical sampling results in 1977 indicated the presence of groundwater contamination associated with Basin 1 (PNL-6470, p. 19). Due to known groundwater contamination, a facility-specific, RCRA compliance groundwater monitoring program for the 183-H Solar Evaporation Basins started in June 1985, as described in PNL-6470.

The 1985 compliance monitoring program was intended to meet 40 CFR 265.90(d), "Applicability," and WAC 173-303-400 but was determined to have an inadequate well network by Ecology. This determination resulted in a regulatory order (EPA and Ecology, 1986). In 1986 and 1987, 18 monitoring wells were installed, and a compliance plan (PNL-6470) was developed in response to the regulatory order (EPA and Ecology, 1986). Analytes monitored at all wells include temperature, pH, specific conductance, coliform bacteria, metals (aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, manganese, mercury, nickel, potassium, selenium, silver, sodium, vanadium, and zinc), anions (chloride, fluoride, nitrate, and sulfate), volatile organic compounds (1,1,1-trichloroethane, perchloroethylene, chloroform, and methylene chloride), pesticides, herbicides, total organic halogens, total organic carbon, ammonium ion, hydrazine, gamma scan, total alpha-emitters, total beta-emitters, gamma emitters, radium, uranium, and strontium-90 (PNL-6470, pp. 32-39). Two wells (199-H3-1 and 199-H4-3) were sampled for additional constituents that are identified in WAC 173-303-9905, "Dangerous Waste Constituents List" (PNL-6470, p. 33).

The 1986 monitoring plan (PNL-6470) was incorporated into the 1988 closure/post-closure plan (DOE/RL-88-04, Rev. 1) with the removal of hydrazine and the addition of phenol to the standard list of analyses. WCH-SD-EN-AP-180 (Section 4.7.1) reports that in May 1989, each of the monitoring wells in the network was analyzed for an extensive list of constituents that included those listed in WAC 173-303-9905, plus those constituents listed in 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," that are not included in WAC 173-303-9905. The monitoring data indicated that most of the WAC 173-303-9905 constituents were below regulatory standards and continued monitoring was no longer needed. The monitoring plan was subsequently modified in 1990 to remove the WAC 173-303-9905 constituents and strontium-90 and add phosphate, total carbon, total dissolved solids, 1,1,2-trichloroethane, tetrachloroethene, xylene, hexone, radium, and technetium-99 to the standard list of analyses for groundwater samples (DOE/RL-88-04, Rev. 2). Under DOE/RL-88-04 (Rev. 2 and 3), 23 wells surrounding the basins were to be sampled on a monthly or quarterly basis until closure activities were concluded.

The 1994 Hanford Facility RCRA Permit required groundwater monitoring programs under final status to comply with requirements of WAC 173-303-645. Accordingly, a final status compliance monitoring program for the 183-H Solar Evaporation Basins (WHC-SD-EN-AP-180) began in 1995. Previous monitoring had included up to 23 wells, many of which were outside the area influenced by the basins. Information from these wells defined the contaminant plume boundaries and provided groundwater chemistry data for the larger 100-H Area. The wells identified in WHC-SD-EN-AP-180 were intended to meet the requirements of compliance monitoring of the identified constituents of concern (nitrate, chromium, uranium, and technetium-99) and represented conditions upgradient of the basins as well as in the most contaminated zone downgradient of the basins. The network consisted of eight wells: 199-H4-6 and 199-H3-2A (upgradient) and 199-H4-3, 199-H4-4, 199-H4-9, 199-H4-12A, 199-H4-18, and 199-H4-12C (downgradient). Groundwater samples were collected semiannually and analyzed for nitrate, chromium, uranium, and technetium-99.

The first sample set collected under the 1995 compliance monitoring plan showed that downgradient concentrations of nitrate, chromium, uranium, and technetium-99 exceeded concentration limits identified in the monitoring plan (WHC-SD-EN-AP-180). The exceedance was reported to Ecology through a letter in 1996 (Furman, 1996). Corrective action groundwater monitoring at the 183-H Solar Evaporation Basins, as required in WAC 173-303-645(11), was then initiated in 1997 under PNNL-11573. The corrective action groundwater monitoring plan (PNNL-11573) was incorporated into the post-closure plan (DOE/RL-97-48) in 1997 and the Hanford Facility RCRA Permit. The corrective action was implemented through the interim remedial action under CERCLA for the 100-HR-3 Groundwater OU.

Groundwater monitoring under PNNL-11573 included sampling from a network of four wells (199-H4-3, 199-H4-7, 199-H4-12A, and 199-H4-12C). These wells were identified based on their location within the chromium plume and met the monitoring objective of tracking concentration trends in the contaminant plume during the IRM. None of these wells were upgradient wells because of changes in the flow system from pump and treat activities and river stage effects. Samples were collected annually and analyzed for dangerous waste constituents (chromium and nitrate), waste indicators (technetium-99 and uranium), additional constituents to aid data interpretation (alkalinity, anions [chloride and sulfate], and selected metals [aluminum, antimony, barium, beryllium, cadmium, calcium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc]), and field parameters (pH, specific conductance, temperature, and turbidity). Fluoride was also monitored as an indicator of 183-H contamination in groundwater because of previous releases from Basin 1. Water level measurements were collected each time a sample was obtained from a network well.

Hexavalent chromium samples are often collected from 183-H monitoring wells, as part of the CERCLA monitoring program. The hexavalent chromium plume for high and low river stage of 2014 are presented in Figures 2-8 and 2-9. The hexavalent chromium plume near well 199-H4-86, shown on Figure 2-8, is likely associated with waste site 100-H-46, while the plume near the river appears to be associated with the 183-H Solar Evaporation Basins (Figure 2-8 and 2-9).

Since its issuance in 1997, two changes to the well network identified in PNNL-11573 were made to accommodate waste site remediation. In 2005, well 199-H4-7 was removed from the monitoring network and replaced with well 199-H4-8. The Hanford Facility RCRA Permit was modified to incorporate this change. In 2013, the permit was again modified to change the monitoring network because well 199-H4-3 required decommissioning due to its proximity to an active soil remediation site. Well 199-H4-84 was added to the network in May 2013 to replace 199-H4-3. Ecology approved this revision by letter (13-NWP-051, "Approval of 13-EMD-0019, Class 2 Modification to the Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste, Part VI, Post-Closure Unit 2, 183-H Solar Evaporation Unit (T-1-4) WA7890008967").

Chromium at the 183-H Solar Evaporation Basins is attributed to both the waste disposal activities at the basins and from other sources. The 1996 chromium plume clearly demonstrates the upgradient contribution (Figure 2-10). Chromium continues to be present at the basins and monitoring under the Hanford Facility RCRA Permit will continue.

As with chromium, nitrate contamination was the result of multiple sources. Historically, the highest concentrations of nitrate were found in wells 199-H4-18 and 199-H4-69, located to the south of the basins. In 2013 and 2014, nitrate concentrations in 100-H Area did not exceed the 45 mg/L DWS[11] (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*; DOE/RL-2015-07). In 2012, four wells at and near the 183-H Solar Evaporation Basins exceeded the nitrate DWS with a peak concentration of 135 mg/L at 199-H4-84 in August 2012 (DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*; Appendix D).

Uranium, technetium-99, and fluoride are removed from 183-H Solar Evaporation Basins monitoring under this plan. Uranium is attributed to the basins and monitoring of uranium is performed under CERCLA. Technetium-99 concentrations have been below the maximum contaminant level (MCL) since 2005, and fluoride has not been detected above the MCL. Technetium-99 monitoring is performed under the AEA groundwater monitoring program (DOE/RL-2015-56). Monitoring of fluoride will be discontinued.

Under this monitoring plan, the network is modified to replace well 199-H4-12A with 199-H4-85, which is closer to the site, and remove 199-H4-12C. Well 199-H4-12C is an extraction well that is completed in the first water bearing unit of the RUM unit, a confined aquifer. As reported in SGW-52135, *First Semiannual Report for 2011 Post-Closure Corrective Action Groundwater Monitoring at the 183-H Solar Evaporation Basins and 300 Area Process Trenches: January-June 2011* (Section 2.3), chromium concentrations from well 199-H4-12C reflect contamination from past releases that entered the RUM.

[11] Nitrate may be expressed as nitrate-nitrogen (NO_3-N) or as nitrate (NO_3). The drinking water standard for NO_3-N is 10,000 µg/L, and the mathematical equivalent value for nitrate (NO_3) is 45,000 µg/L.

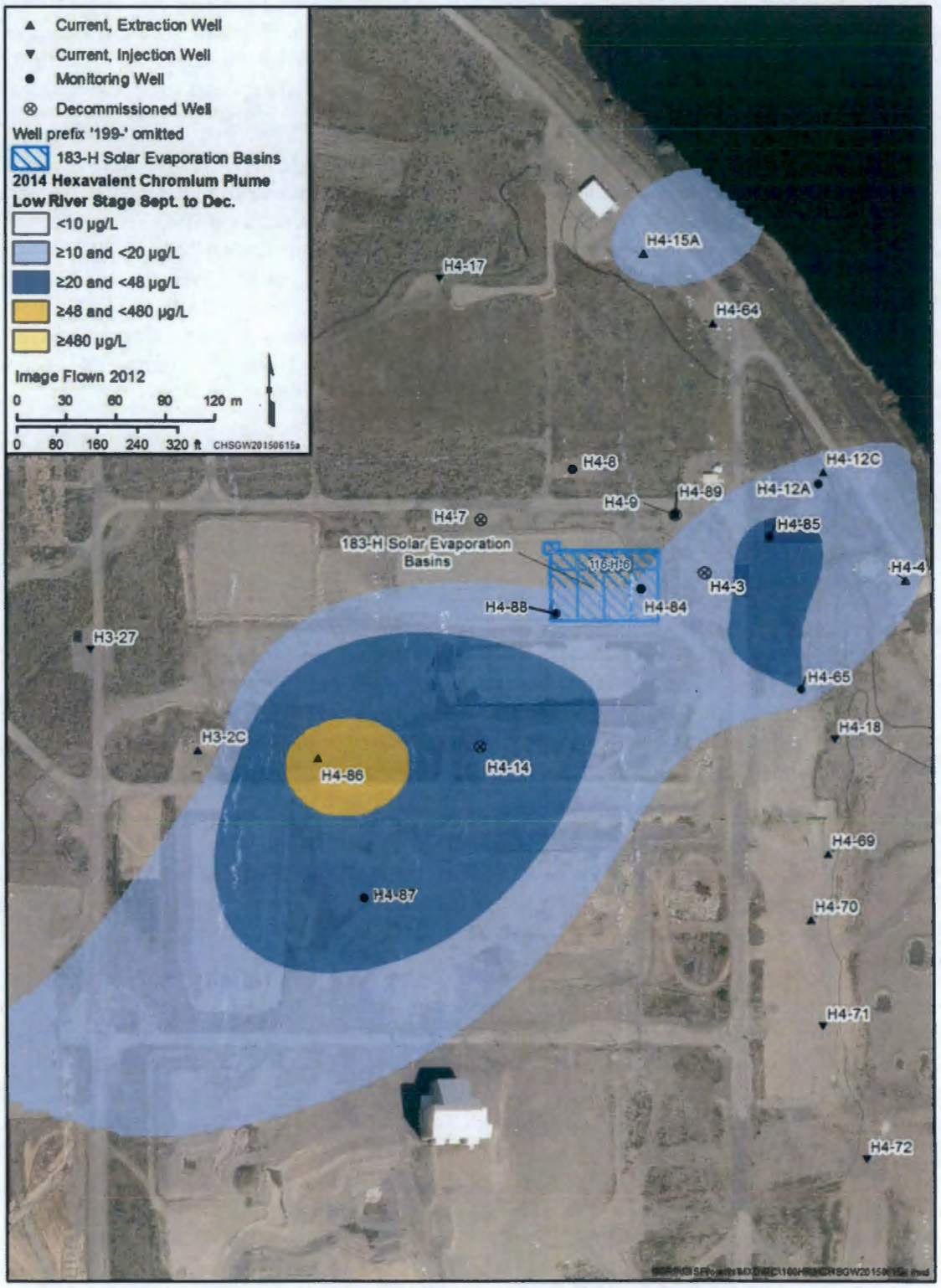
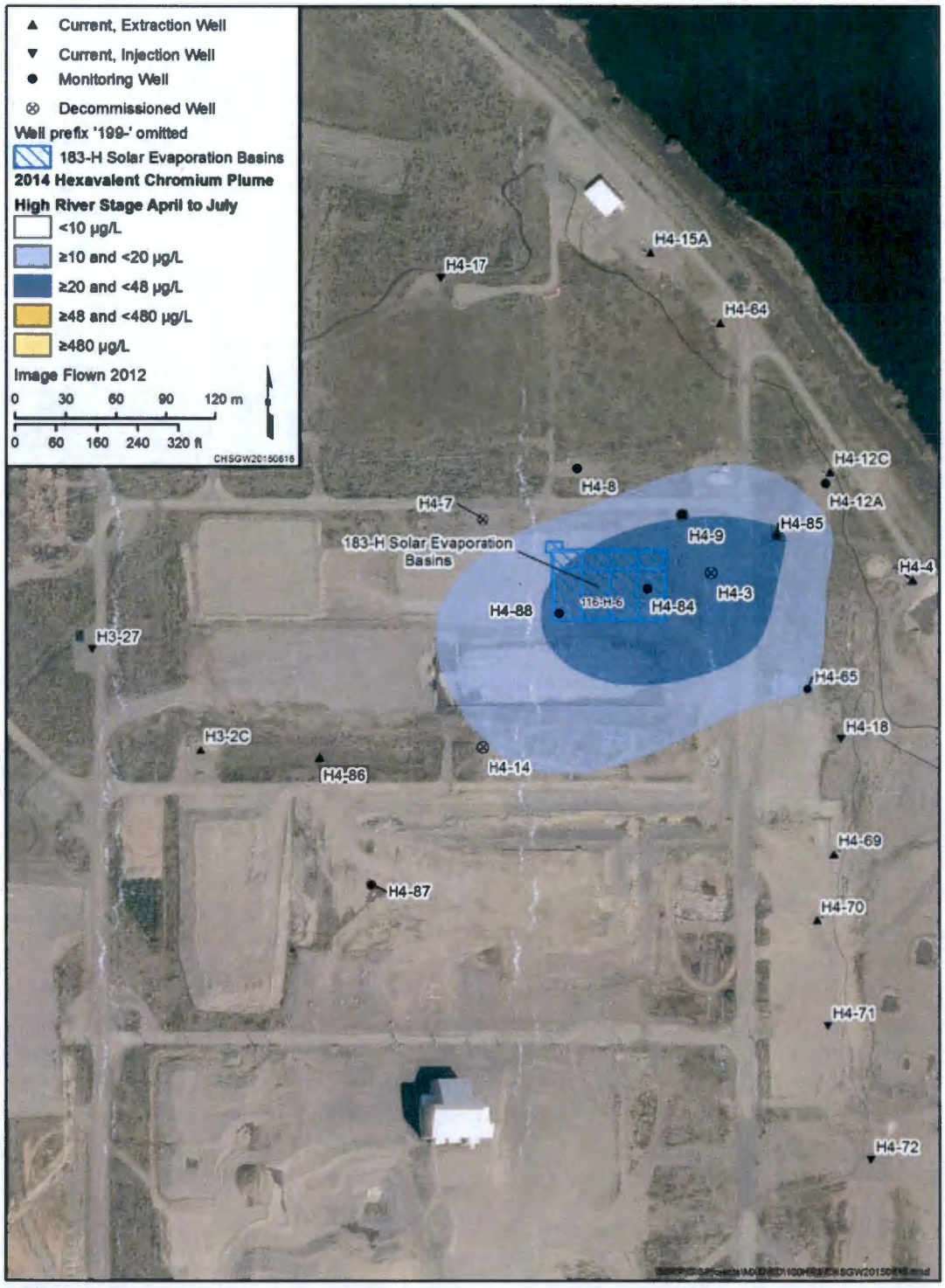


Figure 2-8. 2014 Hexavalent Chromium Plume during Low River Stage (September to December)



Note: High and low river stage are evaluated each year based on actual flows. For the year presented (2014) high river stage occurred from April through the end of July (DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014* [Figure 4-6]).

Figure 2-9. 2014 Hexavalent Chromium Plume during High River Stage (April through July)

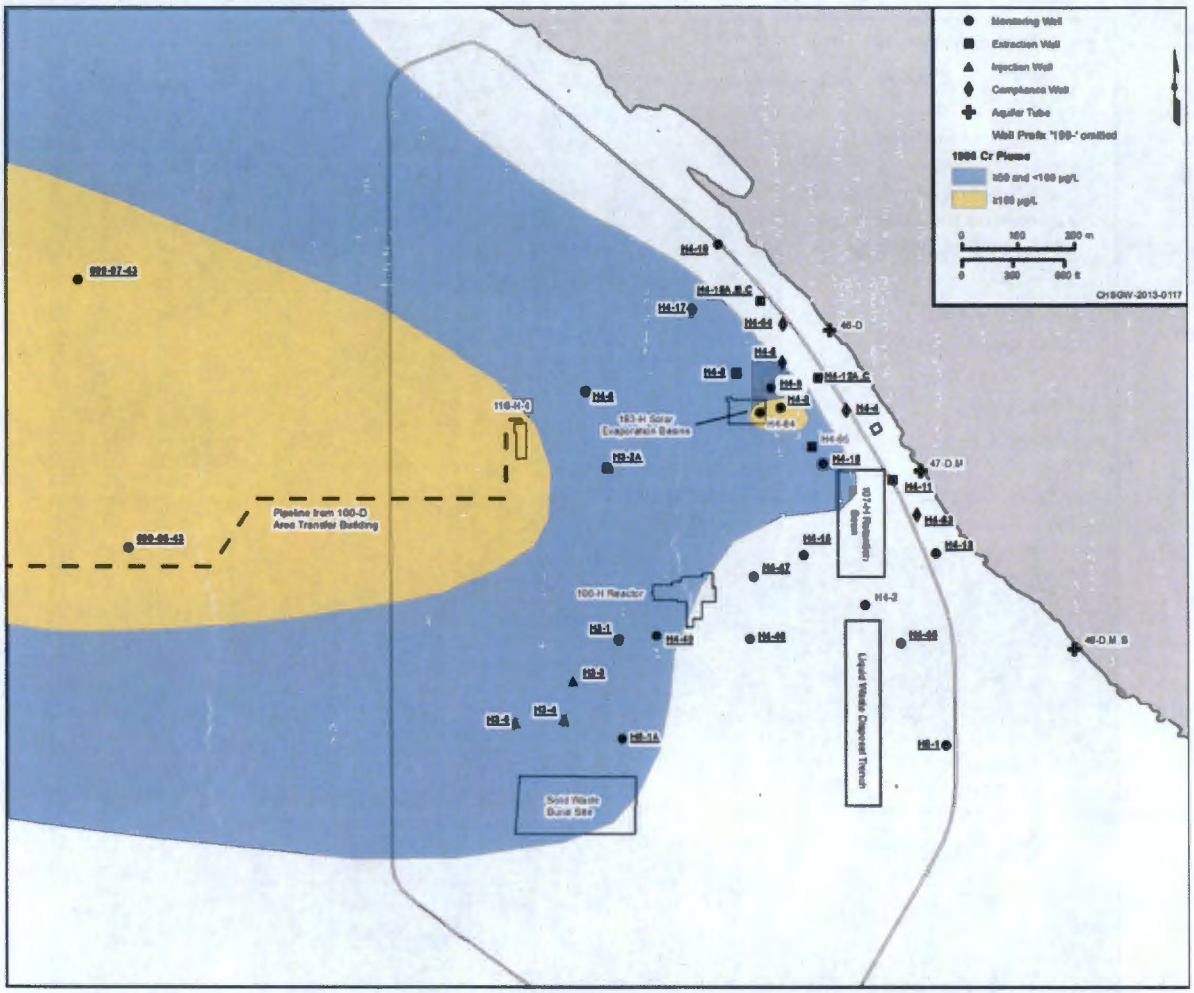


Figure 2-10. 100-H Area Chromium Plume in 1996

Hexavalent chromium levels in well 199-H4-12C declined from approximately 300 µg/L in the early 1990s, and were stable until 2009, when the well was connected to the 100-HR-3 pump and treat system (see Appendix D, Figure D-5). After the connection, hexavalent chromium concentrations climbed, as contaminated groundwater was pulled towards the extraction well. This conclusion is also supported by observation that basin co-contaminants (i.e., nitrate, technetium-99, and uranium) are not elevated in well 199-H4-12C (SGW-52135, Section 2.3), and that the 100-H aquifer test and rebound study suggests that there is low communication between the unconfined aquifer and the confined aquifer at this location (SGW-47776, *Aquifer Testing and Rebound Study in Support of the 100-H Deep Chromium Investigation*, Section 4.1).

This plan includes three existing monitoring wells (199-H4-8, 199-H4-84, and 199-H4-85) and two additional new monitoring wells (199-H4-88 and 199-H4-89), which were drilled 2016. The sampling frequency is modified from annual to semiannual. The new wells will be sampled quarterly for two years to obtain sufficient data for statistical evaluation. Samples will be analyzed semiannually for total chromium (filtered), nitrate, and field parameters under this plan. Water level measurements are collected each time a sample is obtained from a network well. Most of the network wells also are included in the annual comprehensive March water level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results

for the 183-H Solar Evaporation Basins are reported on a semiannual basis per WAC 173-303-645(11)(g) and are summarized annually in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

2.6 Conceptual Site Model

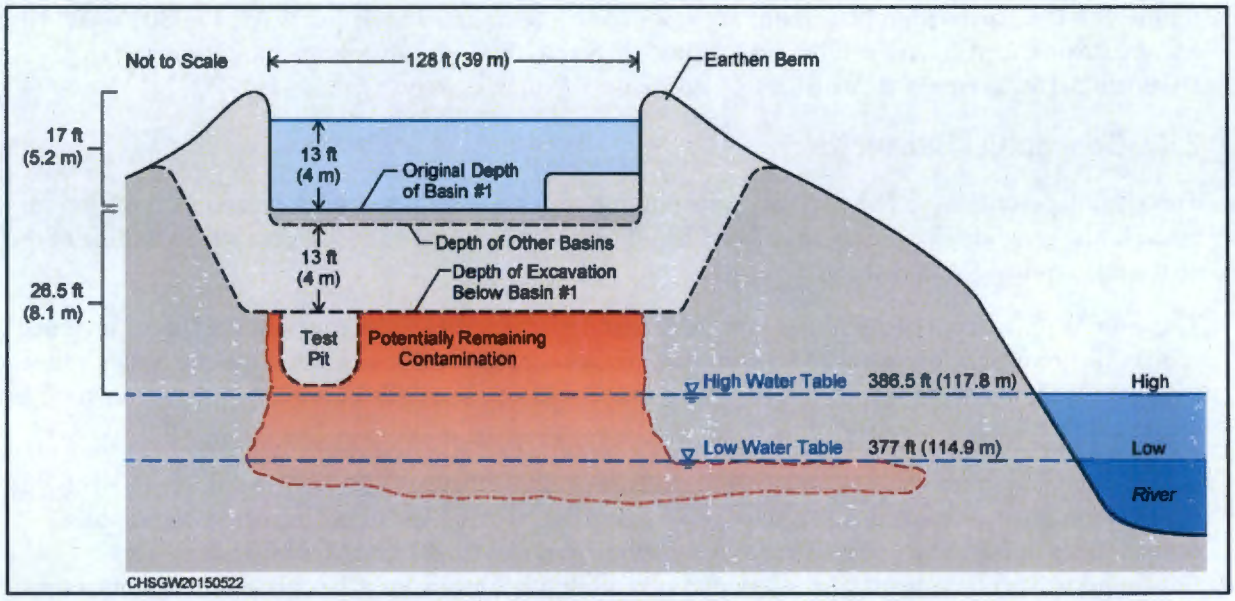
This section describes the 183-H Solar Evaporation Basins CSM for potential contaminant transport to guide future groundwater monitoring. The CSM (Figure 2-11) describes the current understanding of the contaminant release and transport.

The most likely sources of chromium contamination from the 183-H Solar Evaporation Basins included sodium dichromate dihydrate used for corrosion control in reactor cooling water when the basins were used as a water treatment facility and the liquid waste discharged into the basins when they were used as evaporation basins.

Source remediation removed the engineered structure and soil contaminants underneath the 183-H Solar Evaporation Basin as necessary to reduce or eliminate the potential for: direct exposure, migration of contaminants through the vadose zone to the groundwater, and wind-blown suspended particles. Dangerous waste constituents of concern during remediation were arsenic, hexavalent chromium, copper, fluoride, nitrate, and nickel (DOE/RL-97-48, Table 1-1). Remediation extended to 0.6 m (2 ft) beneath each basin. Below Basin 1, additional soil was removed to depths of up to 4.6 m (15 ft) below the former structure (DOE/RL-97-48). A test pit below Basin 1 was dug to 7.6 m (25 ft) (DOE/RL-97-48, Section 1.2.4). DOE/RL-97-48 does not specify whether the Basin 1 test pit depth is measured from ground surface or from the excavation depth, however, the test pit results represent soil at least 7.6 m (25 ft) bgs. Both nitrate and fluoride contamination were identified at this depth (DOE/RL-97-48, Section 1.2.4). Since removal of the source of contamination (the basin liquids) in the late 1980s, contaminant concentrations in the groundwater have declined. However, at the time of closure, the extent of remaining contamination extended from a depth of 4.6 m (15 ft) below the bottom of the basin structure to groundwater, and appeared to include fluoride and nitrate (DOE/RL-97-48, Section 1.2.4).

An evaluation of the borehole and Basin 1 test pit sample results for the 183-H Solar Evaporation Basins was performed as part of the CERCLA remedial investigation/feasibility study conducted in 2009 through 2010 (DOE/RL-2010-95, Section 4.3.17). In 1991, eight boreholes were drilled in and around the basins. Of the four boreholes within the basins (A5716/17/18/19), the depths ranged from 9.6 m (31.5 ft) to 10.2 m (33.4 ft) bgs. Of the four boreholes outside of the basins (A5720/21/22/23), the depths ranged from 11.3 m (37.0 ft) to 17.3 m (56.9 ft) bgs. In 2011, a borehole within the Basin 1 footprint was drilled to 14.8 m (48.6 ft) bgs.

Contaminant distribution in individual boreholes indicated that technetium-99, strontium-90, and tritium concentrations increased with depth, but their levels were typically <2 to 7 pCi/g (Table 2-2). Nitrate reached a maximum of 304 mg/kg at 10.2 m (33.4 ft) bgs, while hexavalent chromium concentrations were <2 mg/kg beneath the site. Only eight contaminants (cobalt-60, technetium-99, antimony, cadmium, lead, selenium, nitrite, and fluoride) either were detected in the vadose zone (those with no background concentration established) or were present above background levels from boreholes adjacent to the site (Table 2-2). Detecting fewer contaminants adjacent to the site suggests that transport was mainly vertical beneath the site with little lateral spreading in the vadose zone. Hexavalent chromium and nitrate were the only contaminants detected above the MCLs in groundwater (48 µg/L and 45 mg/L, respectively) beneath this site in 2009. From amongst the monitoring well network since 2010, hexavalent chromium continues to be detected above the MCL (48 µg/L) in well 199-H4-12C (Appendix D). Nitrate above the MCL (45 mg/L) was detected at wells 199-H4-3 (2011, 2012), 199-H4-12A (2012), and 199-H4-84 (2012) (Appendix D).



Note: Water table elevations are in NAVD88, *North American Vertical Datum of 1988*.

Figure 2-11. Conceptual Site Model for the 183-H Solar Evaporation Basins

Table 2-2. Summary of Soil Contaminants Detected above Background at the 183-H Solar Evaporation Basin Boreholes

Contaminant	Maximum Result[a,b] (pCi/g) with Corresponding Depth (m/ft) bgs	Borehole (Sampling Year)	Extent of Detection Above Background (m/ft) bgs	Result (pCi/g)[c]	Borehole (Sampling Year)
Cobalt-60	0.01 (7.8/25.6)	A5720 (1991)	7.8/25.6	0.01	A5720 (1991)
Strontium-90	0.365 (11.3/37.0)	C7860 (2011)	11.3/37.0	0.365	C7860 (2011)
Technetium-99	6.6 (10.2/33.4)	A5716 (1991)	14.3/46.9	0.5	A5720 (1991)
Tritium	6.35 (8.3/27.1)	C7860 (2011)	13.1/43.0	4.96	C7860 (2011)
Contaminant	**Maximum Result[a] (mg/kg) with Corresponding Depth (m/ft) bgs**	**Borehole (Sampling Year)**	**Extent of Detection Above Background (m/ft) bgs**	**Result (mg/kg)[c]**	**Borehole (Sampling Year)**
Antimony	19.2 (9.8/32.0)	A5718 (1991)	14.8/48.6	0.292	C7860 (2011)
Cadmium	4.5 (6.4/21.0)	A5721 (1991)	9.6/32.0	0.6	A5718 (1991)

Table 2-2. Summary of Soil Contaminants Detected above Background at the 183-H Solar Evaporation Basin Boreholes

Contaminant	Maximum Result[a] (mg/kg) with Corresponding Depth (m/ft) bgs	Borehole (Sampling Year)	Extent of Detection Above Background (m/ft) bgs	Result (mg/kg)[c]	Borehole (Sampling Year)
Fluoride	10.5 (10.2/33.4)	A5716 (1991)	11.4/37.4	4.2	A5722 (1991)
Lead	36.5 (3.8/12.6)	C7860 (2011)	11.4/37.4	11.9	A5722 (1991)
Nitrite	5.0 (9.8/32.0)	A5718 (1991)	9.8/32.0	5.0	A5718 (1991)
Selenium	3.9 (9.8/32.0)	A5718 (1991)	9.8/32.0	3.9	A5718 (1991)

Reference: DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Appendix D, Tables D-91, D-92, and D-93

a. Eight of the boreholes included in the DOE/RL-2010-95 evaluation were sampled in 1991, before remediation of the 183-H Solar Evaporation Basins. The remediation depth for the site reported in the DOE/RL-2010-95 is 2.7 m (9 ft) bgs, with a remediation depth of 6.1 m (20 ft) bgs at Basin 1. To present results that represent depths below remediation, only results from sampling depths greater than 2.7 m (9 ft) bgs for the eight 1991 boreholes are considered in this summary table, except for borehole A5716 which was located within Basin 1. For A5716, results from sampling depths greater than 6.1 m (20 ft) bgs are considered for the summary. All results for C7860, drilled in 2011, are considered for the summary.

b. Radionuclide activities are decayed to 2012 (DOE/RL-2010-95).

c. Maximum result from amongst the deepest samples collected at each of the nine, 183-H Solar Evaporation Basin boreholes evaluated in DOE/RL-2010-95.

bgs = below ground surface

The hydraulic and geochemical properties of this region control the downward movement of liquids and contaminants released near ground surface. Any residual contaminants that remain in the vadose zone after the cessation of waste discharges can migrate downward by any of four mechanisms:

- Contaminants may continue to move by gravity drainage of residual wastewater within the vadose zone (this process is not believed to be continuing at this time).
- Contaminants may be mobilized in the fraction of annual precipitation that actually percolates deep into the vadose zone to recharge into the aquifer (this process may be ongoing if contaminants are present in the vadose zone).
- Contaminants may be mobilized into groundwater from the vadose zone during seasonal increases in groundwater table elevation resulting from high river stages (this process may be ongoing if contaminants are present in the vadose zone).
- Contaminants may be mobilized in water added for dust control during remedial actions (for example, excavation) and migrate deeper into the vadose zone (this process may be ongoing if contaminants are present in the vadose zone).

At 183-H, chromium continues to be detected in the groundwater at the site. This indicates the chromium is present in the vadose zone soil. During periods of high river stage, some of this chromium is released into the groundwater. Chromium concentrations appear to fluctuate seasonally in response to changing river stage at the 183-H Solar Evaporation Basins. The chromium concentrations typically rise when groundwater elevations are low in the wells located downgradient from the basins. This correlation is also seen in specific conductance, indicating that there is less river water in the aquifer during low water periods. This further suggests there is remaining contamination in the vadose zone that is mobilized to groundwater during elevated water table periods. The chromium concentrations in the vicinity of the 183-H Solar Evaporation Basins have been below 48 µg/L in the unconfined aquifer since 2005 (as shown in Appendix D). Chromium concentrations within the first water bearing unit of the RUM continue to have chromium concentrations near 120 µg/L, however the contamination in that aquifer have been determined to not originate from the basins and monitoring of that aquifer is not included in this plan.

2.7 Corrective Action and Groundwater Monitoring Requirements

The groundwater monitoring program at 183-H Solar Evaporation Basins is conducted with the objectives identified in WAC 173-303-645, as required by the Hanford Facility RCRA Permit, Part II, Condition II.F. Corrective action groundwater monitoring is implemented in accordance with WAC 173-303-645(11), which requires the establishment and implementation of a groundwater monitoring program that is capable of demonstrating the effectiveness of the corrective action, currently pump and treat. This requirement states two general objectives:

The corrective action groundwater monitoring program may be based on the requirements for a compliance monitoring program under WAC 173-303-645(10) and must be as effective as that program in determining compliance with the groundwater protection standard under WAC 173-303-45(3).

Monitoring during corrective actions must be capable of determining the effectiveness of the corrective action program.

Table 2-3 identifies where each groundwater monitoring element of the pertinent applicable regulations is addressed within this plan.

WAC 173-303-645(11) includes requirements for a corrective action program. Part VI, Post Closure Unit 2, Chapter 4 of the Hanford Facility RCRA Permit contains the corrective action plan for the 183-H Solar Evaporation Basins. The plan specifies that groundwater corrective action to remove hexavalent chromium is being undertaken as an interim remedial measure under CERCLA for the entire 100-HR-3 OU. The CERCLA action is not under the purview of this groundwater monitoring plan. Table 2-4 identifies where elements of corrective action under WAC 173-303-645(11) are discussed within this groundwater monitoring plan. Some components of the corrective action requirements also apply to groundwater monitoring requirements and are incorporated within Table 2-3, as appropriate.

Table 2-3. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Groundwater Monitoring Program	WAC 173-303-645(11) "Corrective Action Program": (d) In conjunction with a corrective action program, the owner or operator must establish and implement a groundwater monitoring program to demonstrate the effectiveness of the corrective action program. Such a monitoring program may be based on the requirements for a compliance monitoring program under subsection (10) of this section, and must be as effective as that program in determining compliance with the groundwater protection standard under subsection (3) of this section, and in determining the success of a corrective action program under (e) of this subsection, where appropriate.	Section 3.1 Section 3.2 Section 3.3 Section 3.4 Section 3.5 Section 3.7 Section 4.1 Section 4.2
Groundwater Protection Standard	WAC 173-303-645(3) "Groundwater Protection Standard": Conditions specified in the facility permit are designed to ensure that dangerous constituents under WAC 173-303-645(4), detected in the groundwater from a regulated unit do not exceed the concentration limits under WAC 173-303-645(5), in the uppermost aquifer underlying the waste management area beyond the point of compliance under WAC 173-303-645(6), during the compliance period under WAC 173-303-645(7).	Section 3.2
Dangerous Constituents	WAC 173-303-645(4) "Dangerous Constituents": (a) The facility permit will specify the dangerous constituents to which the groundwater protection standard of WAC 173-303-645(3) applies.	Section 3.1
Concentration Limits	WAC 173-303-645(5) "Concentration Limits": (a) The facility permit will specify concentration limits in the groundwater for the dangerous constituents established under WAC 173-303-645(4) of this section. (ii) For constituents listed in Table 1, the concentration limit must not exceed the value given in that table if the background level of the constituent is below the value given in Table 1.	Section 3.2
Point of Compliance	WAC 173-303-645(6) "Point of Compliance": The facility permit will specify the point of compliance at which the groundwater protection standard WAC 173-303-645(3) applies and at which monitoring must be conducted. The point of compliance is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.	Section 3.3

Table 2-3. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Compliance Period	WAC 173-303-645(7) "Compliance Period": (a) The facility permit will specify the compliance period during which the groundwater protection standard of WAC 173-303-645(3) applies. The compliance period is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period). (c) If the owner or operator is engaged in a corrective action program at the end of the compliance period specified in (a), the compliance period is extended until the owner or operator can demonstrate that the groundwater protection standard of WAC 173-303-645(3) has not been exceeded for a period of three consecutive years.	Section 3.4 Section 4.2 Appendix D
Number and Location of Wells	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (a) The groundwater monitoring system must consist of a sufficient number of wells, installed at appropriate locations and depths to yield groundwater samples from the uppermost aquifer that: (i) Represent the quality of background groundwater that has not been affected by leakage from a regulated unit; (ii) Represent the quality of groundwater passing the point of compliance. (iii) Allow for the detection of contamination when dangerous waste or dangerous constituents have migrated from the waste management area to the uppermost aquifer.	Section 3.5
Well Configuration	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must allow collection of representative groundwater samples. Wells must be constructed in such a manner as to prevent contamination of the samples, the sampled strata, and between aquifers and water bearing strata. Wells must meet the requirements applicable to resource protection wells, which are set forth in Chapter 173-160 WAC, "Minimum standards for construction and maintenance of wells."	Section 3.5 Appendix C
Frequency of Sampling Water Level Measurements	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (f) The groundwater monitoring program must include a determination of the groundwater surface elevation each time groundwater is sampled. (g) The owner or operator will determine an appropriate sampling procedure and interval for each hazardous constituent listed in the facility permit.	Section 3.1 Appendix B, Section B2.2
Procedures and Techniques	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (d) The groundwater monitoring program must include at a minimum, procedures and techniques for: (i) Decontamination of drilling and sampling equipment; (ii) Sample collection;	Appendix A, Appendix B, Chapter B2 and Sections B5.1, B5.2, and B5.3

Table 2-3. Pertinent WAC 173-303-645 Corrective Action Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
	(iii) Sample preservation and shipment; (iv) Analytical procedures and quality assurance; and (v) Chain of custody control. (e) The groundwater monitoring program must include consistent sampling and analytical methods that ensure reliable groundwater sampling, accurately measure dangerous constituents and indicator parameters in groundwater samples, and provide a reliable indication of groundwater quality below the waste management area.	
Statistical Evaluation Statistical Methods	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (h) Groundwater monitoring data will be evaluated using a specified statistical method. The statistical test will be conducted separately for each dangerous constituent in each well. A statistical method not specified in the subsection may be submitted for approval. (i) The statistical method must be appropriate for the distribution of the dangerous constituent. The practical quantification limit used in the statistical method must be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.	Section 4.2 Appendix A, Section A3.1
Recordkeeping and Reporting	WAC 173-303-645(8) "General Groundwater Monitoring Requirements": (j) Groundwater monitoring data collected in accordance with WAC 173-303-645(8)(g) including actual levels of constituents must be maintained in the facility operating record. The permit specifies when the data must be submitted for review.	Appendix A, Sections A2.6 and A3.9

Note: Complete citations for references listed in this table are provided in Chapter 5 of this plan.

* Part II, Condition II.F of the Hanford Facility RCRA Permit specifies that a groundwater monitoring program under final status is subject to the requirements of WAC 173-303-645. Because of previous exceedances of the prescribed concentration limits identified in the previous monitoring plan (PNNL-11573), the 183-H Solar Evaporation Basins are subject to corrective action monitoring under WAC 173-303-645(11).

WAC = *Washington Administrative Code*

Table 2-4. Pertinent WAC 173-303-645(11) Corrective Action Requirements

Corrective Action Element	Pertinent Requirement	Section Where Requirement is Discussed in Monitoring Plan
Corrective Action Program	WAC 173-303-645(11) "Corrective Action Program" : (a) Corrective action to ensure that regulated units comply with the groundwater protection standard under WAC 173-303-645(3). The groundwater protection standard will be specified in the facility permit, including: (i) A list of the dangerous constituents and parameters identified under WAC 173-303-645(4); (ii) Concentration limits under WAC 173-303-645(5), for each of those dangerous constituents and parameters; (iii) The compliance point under WAC 173-303-645(6); and (iv) The compliance period under WAC 173-303-645(7).	Section 3.1 Section 3.2 Section 3.3 Section 3.4
Corrective Action	(b) The owner or operator must implement a corrective action program that prevents dangerous constituents and parameters from exceeding their respective concentration limits at the compliance point by removing the dangerous waste constituents and parameters or treating them in place. The permit will specify the specific measures that will be taken. (c) The owner or operator must begin corrective action within a reasonable time period after the groundwater protection standard is exceeded. The department will specify that time period in the facility permit. (e) In addition to the other requirements of this section, the owner or operator must conduct a corrective action program to remove or treat in place any dangerous constituents or parameters under subsection (4) of this section, that exceed concentration limits under subsection (5) of this section, in groundwater between the compliance point under subsection (6) of this section, and the downgradient facility property boundary; and beyond the facility boundary, where necessary to protect human health and the environment, unless the owner or operator demonstrates to the satisfaction of the department that, despite the owner's or operator's best efforts, the owner or operator was unable to obtain the necessary permission to undertake such action. The owner/operator is not relieved of all responsibility to clean up a release that has migrated beyond the facility boundary where off-site access is denied. On-site measures to address such releases will be determined on a case-by-case basis. For a facility seeking or required to have a permit, the corrective action measures to be taken must be specified in the permit. (f) The owner or operator must continue corrective action measures during the compliance period to the extent necessary to ensure that the groundwater protection standard is not exceeded. If the owner or operator is conducting corrective action at the end of the compliance period, he must continue that corrective action for as long as necessary to achieve compliance with the groundwater protection standard. The owner or operator may terminate corrective action measures taken beyond the period equal to the active life of the waste management area	Section 2.2 Section 3.4

Table 2-4. Pertinent WAC 173-303-645(11) Corrective Action Requirements

Corrective Action Element	Pertinent Requirement	Section Where Requirement is Discussed in Monitoring Plan
	(including the closure period) if he can demonstrate, based on data from the groundwater monitoring program under (d) of this subsection, that the groundwater protection standard of subsection (3) of this section, has not been exceeded for a period of three consecutive years.	
Recordkeeping and Reporting	WAC 173-303-645(11) "Corrective Action Program:" (g) The owner or operator must report in writing to the department on the effectiveness of the corrective action program. The owner or operator must submit these reports semiannually. (h) If the owner or operator determines that the corrective action program no longer satisfies the requirements of this section, he must, within forty-five days, submit an application for a permit modification to make any appropriate changes to the program.	Section 4.4

Note: The references cited in this table are listed in the reference section (Chapter 5) of this plan.

WAC = *Washington Administrative Code*

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3 Groundwater Monitoring Program

This chapter describes the corrective action groundwater monitoring program for 183-H Solar Evaporation Basins consisting of dangerous waste constituents, field parameters, concentration limit, point of compliance, compliance period, a monitoring well network, and sampling and analysis protocols. The monitoring program presented herein has been revised from that presented in the previous plan (PNNL-11573), and supersedes the monitoring program of the previous plan.

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, constituents analyzed as required for corrective action monitoring, and sampling frequency for monitoring of the 183-H Solar Evaporation Basins. The dangerous waste constituents identified for the 183-H Solar Evaporation Basins are total chromium, collected as a filtered sample, and nitrate. The sampling frequency in this revised plan is changed from annual to semiannual to align with semiannual reporting requirements under WAC 173-303-645(11)(g). Total chromium (filtered) and nitrate will be sampled semiannually with collection scheduled during low river stage (typically September through December) and high river stage (typically April through August) (note: for 2014, high river stage extended from the first part of April through the end of July). Field parameters (pH, specific conductance, temperature, dissolved oxygen, and turbidity) will also be sampled semiannually. New wells (199-H4-88 and 199-H4-89) will be sampled quarterly for the first 2 years to collect sufficient samples to support statistical evaluation (Section 4.2). Water level measurements at each monitoring well will be determined each time a sample is obtained (WAC 173-303-645(8)(f)).

Maintenance problems and sampling logistics resulting from multiple factors including environmental (i.e., inclement weather) and access restrictions (i.e., heightened fire danger, area access restriction due to work by other Hanford contractors such as in the tank farms) sometimes delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well will be sampled. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sampling Management and Reporting group, along with the project scientist, will consult on how best to recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the pre-sampling walkdown that one or more network wells cannot be sampled, then sampling of the well network will not begin and management will be notified. Depending on the situation, the network sampling will be rescheduled within a short time frame (such as 3 to 4 weeks). In some cases, it may not be obvious that sampling cannot be performed until a well is accessed (e.g., an issue with a pump).

Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE-RL and Ecology may agree to resampling wells. DOE-RL will provide informal notification to Ecology if sampling of the network is expected to be delayed for longer than 4 weeks. Ecology may provide input in a timely fashion to DOE-RL on how to proceed. Missed or cancelled sampling events are reported to DOE-RL, and are documented in the semiannual monitoring reports required by WAC 173-303-645(11)(g), and the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

Table 3-1. Monitoring Well Network for the 183-H Solar Evaporation Basins

Well Name	Purpose	WAC Compliant	Dangerous Waste Constituents and Other Parameters[a]							
			Water Level	Dangerous Waste Constituent		Field Parameters				
				Total Chromium (Filtered)	Nitrate	pH	Specific Conductance	Temperature	Dissolved Oxygen	Turbidity
199-H4-8	Corrective Action Monitoring	Y	S	S	S	S	S	S	S	S
199-H4-84	Corrective Action Monitoring	Y	S	S	S	S	S	S	S	S
199-H4-85	Corrective Action Monitoring	Y	S	S	S	S	S	S	S	S
199-H4-88[b]	Corrective Action Monitoring	Y	Q	Q	Q	Q	Q	Q	Q	Q
199-H4-88[c]	Corrective Action Monitoring	Y	S	S	S	S	S	S	S	S
199-H4-89[b]	Corrective Action Monitoring	Y	Q	Q	Q	Q	Q	Q	Q	Q
199-H4-89[c]	Corrective Action Monitoring	Y	S	S	S	S	S	S	S	S

a. Monitoring as required under WAC 173-303-645(11), "Dangerous Waste Regulations," "Releases from Regulated Units," "Corrective Action Program."

b. Sampling frequency for the first 2 years of monitoring.

c. Sampling frequency following the first 2 years of monitoring.

Q = to be sampled quarterly
S = to be sampled semiannually
WAC = *Washington Administrative Code*
Y = well is, or will be, constructed as a resource protection well (WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells")

3.2 Concentration Limit

Dangerous waste constituents from the regulated waste unit may not exceed concentration limits established by the Hanford Facility RCRA Permit (WAC 173-303-645[5]). The concentration limit for total chromium (collected as a filtered sample) in the previous plan (PNNL-11573) was 122 µg/L. This value was determined in WHC-SD-EN-AP-180, based on background concentrations of upgradient wells 199-H3-2A and 199-H4-6. The concentration limit for nitrate was 45 mg/L in PNNL-11573. Concentration limits were applied during compliance monitoring to determine whether corrective action was necessary as required by WAC 173-303-645(10).

Concentration limits of dangerous waste constituents during corrective action are required in WAC 173-303-645(11). The concentration limit for total chromium (collected as a filtered sample) in this plan is 48 µg/L. This concentration represents the WAC 173-340-720(3), "Model Toxics Control Act-Cleanup," "Groundwater Cleanup Standards," "Method B Cleanup Levels for Potable Groundwater," groundwater cleanup level for hexavalent chromium, which is the soluble and mobile form of chromium and is equivalent to total chromium as a filtered sample. The concentration limit for nitrate is 45 mg/L (as NO_3) which is the drinking water standard in 40 CFR 141, "National Primary Drinking Water Regulations." Because of the previous exceedances of the concentration limits and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remediation period do not require additional action.

3.3 Point of Compliance

The point of compliance is defined in WAC 173-303-645(6) as "...a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units." This is the location in the uppermost aquifer where groundwater monitoring occurs and the groundwater protection standard applies. Three existing wells (199-H4-8, 199-H4-84, and 199-H4-85) and two new wells (199-H4-88 and 199-H4-89) are located either at or near the 183-H Solar Evaporation Basins. Wells in the monitoring network (Section 3.5 and Figure 2-1) represent the point of compliance. The wells were identified based on their location in the contaminant plume, extending from the 183-H Solar Evaporation Basins to the Columbia River, and within the general groundwater flow direction toward the river (downgradient). The network wells are screened in the unconfined aquifer.

The point of compliance wells will be monitored to assess the progress of the corrective action (CERCLA remedial action). Concentrations of total chromium (filtered) and nitrate in these wells will be evaluated relative to the concentration limits, in accordance with Section 3.4.

3.4 Compliance Period

The compliance period under WAC 173-303-645(7)(a) is the number of years equal to the active life of the waste management area (including any waste management activity prior to permitting, and the closure period). The 183-H Solar Evaporation Basins began operation in 1973 and were closed in 1997, which is a total of 25 years. Therefore, the compliance period for the 183-H Solar Evaporation Basins is equal to 25 years and will end in year 2022.

Under WAC 173-303-645(7)(c), if a corrective action program is ongoing at the end of the compliance period (year 2022), then the corrective action must continue for as long as necessary to achieve compliance with the concentration limit. The compliance period is extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.

Monitoring for both of the dangerous wastes will continue through the compliance period. However, it is possible that the concentrations of one or both dangerous waste could fall below the concentration limit during the compliance period. If the concentrations are less than the concentration limit for the three year period before the end of the compliance period (years 2019 through 2022), then monitoring will be discontinued at the end of the compliance period. If concentrations of either or both dangerous wastes are not less than the concentration limit in year 2022 (or have not been less than the concentration limit for three consecutive years), then the compliance period will be extended and monitoring for the dangerous waste(s) above the concentration limit will continue until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.

Evaluation methodology for the sampling results is detailed in Section 4.2. Dangerous waste concentrations will be determined with either a 95 percent upper confidence limit (UCL) calculation (for data sets containing detections above the concentration limit) or by visual observation (for data sets containing non-detects and/or detections below the concentration limit). When both dangerous wastes have been below the concentration limit for 3 consecutive years, corrective action monitoring will be discontinued, and the site will be removed from the Hanford Facility RCRA Permit.

3.5 Monitoring Well Network

The current 183-H Solar Evaporation Basins monitoring network consists of five wells. Wells are not specified as upgradient or downgradient since the area is influenced by an active pump and treat system, however the groundwater flow is generally towards the river. Figure 2-1 shows the groundwater monitoring network, and information on the wells is summarized in Table 3-2. Wells 199-H4-3 and 199-H4-9 were decommissioned in 2013 in support of waste site remediation. Monitoring well 199-H4-85 was installed to replace 199-H4-3, and well 199-H4-89 will replace 199-H4-9 as described in DOE/RL-2012-45, *Sampling and Analysis Plan for Installation of 100-HR-3 Groundwater Operable Unit Replacement Wells* and TPA-CN-659, *Tri-Party Agreement Change Notice Form: DOE/RL-2015-45, Sampling and Analysis Plan for Installation of 100-HR-3 Groundwater Operable Unit Replacement Wells.*

As of the last network well change in 2013, the 183-H Solar Evaporation Basins monitoring network included four wells (199-H4-8, 199-H4-12A, 199-H4-12C, and 199-H4-84). This plan updates the monitoring network to remove well 199-H4-12C, an extraction well that is completed in the first water bearing unit of the RUM unit, a confined aquifer. Chromium concentrations from well 199-H4-12C are from historical releases at other sources and not attributable to the 183-H Solar Evaporation Basins (Section 2.5). Also, well 199-H4-12A is replaced with 199-H4-85, which is located closer to the 183-H Solar Evaporation Basins, is completed in the unconfined aquifer.

New wells 199-H4-89 (located downgradient) and 199-H4-88 (located in the southwest corner of the former 183-H Solar Evaporation Basins location) are added to the groundwater monitoring network. In summary, upon Hanford Facility RCRA Permit modification, the monitoring well network will include 199-H4-8, 199-H4-84, 199-H4-85, 199-H4-88, and 199-H4-89.

If a well is within approximately 2 years of going dry, a replacement well will be proposed; such wells are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement Milestone (Ecology et al., 1989) M-24-00. At 100-H Area, the water table is not declining and is directly affected by the Columbia River, so that replacement for dry well conditions is highly unlikely.

Construction details and pertinent information for the wells are provided in Appendix C and include wells in the current network and those proposed.

Table 3-2. Attributes for Wells in the 183-H Solar Evaporation Basins Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Top of Casing Elevation (m [ft]) NAVD88	Total Well Depth[b] (m [ft] bgs)	Water Table Elevation (m [ft]) (amsl)	Water Depth (m [ft] bgs)	Bottom of Screen Depth (m [ft] bgs)	Water Remaining (m [ft])	Water Table Measurement Date
199-H4-8	1986	577860.70	152921.70	129.2 (423.9)[c]	14.6 (47.9)	115.8 (379.7)	12.8 (42.0)	14.6 (47.9)	1.8 (5.9)	5/20/2016
199-H4-84	2011	577902.58	152848.73	128.7 (422.2)[d]	14.6 (47.9)	115.8 (379.7)	12.9 (42.3)	14.5 (47.6)	1.6 (5.2)	5/10/2016
199-H4-85	2013	577980.02	152880.81	128.8 (422.6)[e]	16.0 (52.5)	115.6 (379.0)	12.4 (40.7)	14.4 (47.2)	2.0 (6.6)	5/22/2016
199-H4-88	2016	577850.51	152833.59	131.7 (431.8)	17.7 (58.1)	115.4 (378.4)	15.5 (50.8)	17.7 (58.0)	2.2 (7.2)	6/13/2016
199-H4-89	2016	577923.32	152893.98	129.0 (422.9)	15.1 (49.35)	115.6 (379.0)	12.6 (41.3)	14.1 (46.4)	1.5 (4.9)	6/13/2016

Reference: NAVD88, *North American Vertical Datum of 1988*.

a. Coordinates are in NAD83, *North American Datum of 1983*.

b. Total depth of cased well, not drilled depth.

c. Elevation at top of casing.

d. Elevation at top of outer casing.

e. Elevation at top of pump plate.

amsl = above mean sea level
bgs = below ground surface

3.6 Differences between This Plan and Previous Plan

Table 3-3 identifies the main differences between this plan and the previous groundwater monitoring plan.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Constituents	Dangerous Wastes: Chromium (collected as a filtered sample), Nitrate	Dangerous Wastes: Total chromium (collected as a filtered sample), Nitrate	Fluoride is no longer monitored because it has been below its background groundwater concentration in the monitoring wells throughout the corrective action monitoring period. Monitoring of uranium is conducted under the CERCLA remedial action. Monitoring of technetium-99 is conducted under the AEA monitoring program.
	Waste Indicators: Uranium, Technetium-99, Fluoride	None	
	Additional constituents to aid data interpretation: alkalinity, anions, and metals	None	Alkalinity, anions[b], and metals[b] will be collected under CERCLA monitoring if needed.
	Field parameters: pH, specific conductance, temperature, turbidity	Field parameters: pH, specific conductance, temperature, turbidity, dissolved oxygen	Dissolved oxygen added as a field parameter to supplement dissolved chromium results.
Concentration Limit	Total chromium at 122 µg/L: based on background determination from two upgradient wells Nitrate at 45 mg/L	Total chromium (filtered) at 48 µg/L, which is the WAC 173-340-720 Method B cleanup level for hexavalent chromium in groundwater Nitrate – no change	Total chromium concentration limit is updated to the groundwater cleanup level for hexavalent chromium, which is the soluble and mobile form of chromium and is equivalent to total chromium as a filtered sample.
Point of Compliance	Not identified at the onset of corrective action (pump and treat)	Wells in the groundwater monitoring network	Allows for comparison to the concentration limit and the compliance period standard during the CERCLA remedial action.
Sampling Frequency	Annual	Semiannual Quarterly sampling for 2 years at new wells 199-H4-88 and 199-H4-89	Alignment with semiannual reporting. Quarterly sampling at new wells will be performed for 2 years to collect sufficient samples for statistical evaluation.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
Well Network	3 wells in unconfined aquifer and 1 well in confined aquifer: 199-H4-3 (replaced by 199-H4-84) 199-H4-7 (replaced by 199-H4-8) 199-H4-12A 199-H4-12C	5 wells in unconfined aquifer: 199-H4-8 199-H4-84 199-H4-85 199-H4-88 199-H4-89	Well 199-H4-12C is removed from the network because it is below the unconfined aquifer and monitors contamination from other sources. Well 199-H4-12A is replaced with 199-H4-85, which is closer to the site. Wells 199-H4-3 and 199-H4-7 were previously replaced with 199-H4-8 and 199-H4-84, respectively. New wells 199-H4-88 and 199-H4-89 added to define the point of compliance.
Groundwater Flow Direction	Generally toward the river (east-northeast), and affected by the pump and treat system	Same	No change
Type of Groundwater Monitoring Program	Corrective Action	Same	No change
Compliance Period	As defined in WAC 173-303-645(7): Number of years equal to the active life of the waste management area (including any waste management activity prior to permitting and the closure period). If corrective action is engaged at the end of the compliance period, then the compliance period is extended until it can be demonstrated that the concentration limit has not been exceeded for a period of three consecutive years.	Based on computation per WAC 173-303-645(7), the compliance period for the 183-H Solar Evaporation Basins is 25 years and will end in 2022 (Section 3.4). Monitoring for both dangerous wastes will be performed through the compliance period. At the end of the compliance period, if concentrations of dangerous waste in the point of compliance wells are less than the concentration limit for the final three consecutive years (2019 to 2022), then monitoring will be discontinued. If corrective action is ongoing at the end of the compliance period (year 2022), then the compliance period will be extended until it is demonstrated that the	Identifies the end of the compliance period and requirement to demonstrate that further monitoring is not required.

Table 3-3. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan[a]	Current Plan	Justification Summary
		concentration limit has not been exceeded for a period of three consecutive years. When the compliance period is complete, 183-H Solar Evaporation Basins will be removed from the Hanford Facility RCRA Permit.	
Statistical Evaluation	Not identified at the onset of corrective action (pump and treat)	95 percent UCL on the mean, targeting 8 to 10 samples. Calculation of the 95 percent UCL is not performed for data sets that are less than the concentration limit. Also, the practical quantitation limit must be less than the concentration limit.	Evaluation methods will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved. See Section 4.2 for details.

a. Previous plan is PNNL-11573, *Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins*.

b. Anions and metals collected under CERCLA include:

199-H4-8: hexavalent chromium, nitrate

199-H4-84: hexavalent chromium, nitrate, uranium, antimony, cadmium, cobalt, copper, lead, silver

For new wells 199-H4-88 and 199-H4-89, the list of anions and metals collected under CERCLA will be evaluated after analytical results have been received.

AEA = *Atomic Energy Act of 1954*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR = *Code of Federal Regulations*
MCL = maximum contaminant level
RCRA = *Resource Conservation and Recovery Act of 1976*
UCL = upper confidence interval
WAC = *Washington Administrative Code*

The previous monitoring plan (PNNL-11573) included chromium and nitrate as dangerous waste constituents and technetium-99 and uranium as waste indicators. Fluoride was monitored as an indicator of 183-H Solar Evaporation Basins contamination in groundwater. Additional constituents to aid data interpretation, alkalinity, anions, and metals were analyzed. Field parameters pH, specific conductance, temperature, and turbidity were also included.

This revised plan monitors only total chromium (collected as a filtered sample) and nitrate. Uranium is monitored as part of the CERCLA IRM and technetium-99 is monitored under the AEA groundwater monitoring program (DOE/RL-2015-56). Fluoride will no longer be monitored. Field parameters routinely collected at the wellhead are retained and measurement of dissolved oxygen is added to monitor

the potential for reduction. Collection of alkalinity, anions, and metals is not included; however, these analyses are routinely performed for multiple nearby wells as part of the IRM monitoring.

The sampling frequency in this revised plan is changed from annual to semiannual to align with semiannual reporting requirements under WAC 173-303-645(11)(g).

The concentration limit in the previous plan for chromium (122 μg/L) was determined in 1995 using two upgradient wells to represent the background concentration. The concentration limit for total chromium (filtered) in this plan is 48 μg/L, the WAC 173-340-720 groundwater cleanup level for hexavalent chromium, which is the soluble and mobile form of chromium and is equivalent to total chromium as a filtered sample.

The previous plan from 1997 included wells 199-H4-3, 199-H4-7, 199-H4-12A, and 199-H4-12C. In 2005, 199-H4-7 was removed from the monitoring network and replaced with 199-H4-8. Well 199-H4-3 required decommissioning in 2013 and was replaced with 199-H4-84. Well 199-H4-12C is removed from the monitoring network because it is completed in the confined aquifer and contaminants detected in this well are not associated the 183-H Solar Evaporation Basins. Monitoring well 199-H4-12A is replaced with 199-H4-85, which is located closer to the 183-H Solar Evaporation Basins and is completed in the unconfined aquifer. New wells 199-H4-89 and 199-H4-88 are added to the monitoring network.

The previous plan was issued in 1997 at the onset of the corrective action (pump and treat remedial action under CERCLA) and did not identify point of compliance wells. The current plan identifies the monitoring network wells as representing the point of compliance. Because of the previous exceedances of the concentration limit for chromium and nitrate and the ongoing remedial action, any concentration limit exceedances at the point of compliance during the remedial action period do not require additional action.

The previous plan did not define the compliance period. In the current plan, the end of the compliance period is identified as 2022. If corrective action is ongoing at the end of the compliance period, then the compliance period will be extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years. When the compliance period has ended, then corrective action monitoring will be discontinued, and the site will be removed from the Hanford Facility RCRA Permit.

The previous plan did not include a method for statistical evaluation of the monitoring data. The current plan is updated with a statistical method that will be used to determine if the corrective action (CERCLA remedial action) is progressing as expected and demonstrate that the concentration limit has been achieved. Nonstatistical evaluation of the results will be used for data sets that are below the concentration limit and have a practical quantitation limit less than the concentration limit.

3.7 Sampling and Analysis Protocol

In accordance with the Hanford Facility RCRA Permit, the groundwater protection regulations of WAC 173-303-645 dictate the groundwater sampling and analysis requirements applicable to final status TSD units. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

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4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification tasks are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

The objective of the corrective action monitoring program is to monitor the concentration trends to demonstrate the effectiveness of the corrective action. Accordingly, the objective of the statistical evaluation during the corrective action is to monitor the concentration trends of the dangerous wastes (total chromium, collected as a filtered sample, and nitrate) to confirm that the corrective action is progressing as expected.

In corrective action monitoring, a UCL of the mean can be compared to a fixed regulatory limit to determine with prescribed confidence whether the mean concentration of the target population (population of interest) significantly exceeds the fixed limit (EPA, 1989, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Interim Final Guidance*; EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*). Calculation of UCLs of the mean are routinely calculated using EPA, 2013, ProUCL (Version 5.0.00), a software package developed for EPA that has undergone expansions and upgrades, including the most recent in 2013.

The 95 percent UCL of the mean, hereafter referred to as a 95 percent UCL, calculated with ProUCL (EPA, 2013), is the statistic used to evaluate groundwater data collected under this monitoring plan. Revised versions of ProUCL will be used as they become available. ProUCL calculates an appropriate 95 percent UCL considering data distribution, data set size, skewness of the data, and percentage of nondetects. The ProUCL technical guide recommends data sets include a minimum of eight to ten independent results, with at least four detections within the data set. Replicate samples are not considered independent.

The most recent eight to ten independent monitoring results of each dangerous waste constituent from 183-H Solar Evaporation Basins monitoring wells are the data set used to compute a 95 percent UCL on an intra-well basis. When available, results from the last nine or ten independent sampling events (whichever is the maximum number of results) from a given well are used for the calculation.

Statistical evaluation of results from wells will begin when eight independent samples are available for the 95 percent UCL calculation. Wells 199-H4-84 and 199-H4-85 have been sampled for total chromium (filtered) and nitrate under CERCLA (and the Hanford Facility RCRA Permit for well 199-H4-84) since 2013 (Appendix D) and therefore have additional results available. Results collected for CERCLA monitoring may be included in the data sets used for 95 percent UCL calculation until a sufficient number of samples (eight) is collected under this plan. Wells 199-H4-88 and 199-H4-89 were drilled in 2016 and will be sampled quarterly for the first 2 years. Until eight sample results are available to calculate the 95 percent UCL, non-statistical evaluation of monitoring results to the concentration limit will be performed.

Not all data sets require computation of a 95 percent UCL. When the sample results in the data set comprising eight to ten samples are less than the concentration limit, a nonstatistical or visual analysis of the data (such as presented in Appendix D) is appropriate. In these cases, each result in the data set (eight to ten samples) must be less than the concentration limit. In addition, the practical quantitation limit for each sample in the data set must not exceed the concentration limit.

The 95 percent UCL calculations are performed as necessary for 183-H Solar Evaporation Basins point of compliance well results to support preparation of the semiannual reports required by WAC 173-303-645(11)(g). Any calculated 95 percent UCL values will be compared to the concentration limit in the reports.

As discussed in Section 3.4, if a corrective action program is ongoing at the end of the compliance period (year 2022), then the corrective action must continue and the compliance period is extended until it is demonstrated that the concentration limit has not been exceeded for a period of three consecutive years. However, it is possible that concentrations will be less than the concentration limit for the three consecutive year period before the end of the compliance period (years 2019 through 2022). In this case, monitoring will be discontinued at the end of the compliance period.

The sample frequency may be adjusted during the final three consecutive year time period to obtain additional sample results (eight to ten) for calculation of a 95 percent UCL. After three years of samples are collected, the data will be evaluated as described above. Calculation of a 95 percent UCL, if required, will be performed using the last eight to ten independent samples collected at a given well. The resulting 95 percent UCL is compared to the concentration limit to determine whether the dangerous waste constituent is below the concentration limit. If the 95 percent UCL is below the concentration limit, then monitoring will be discontinued.

4.3 Interpretation

Data are used to interpret groundwater conditions at 183-H Solar Evaporation Basins. Interpretive techniques may include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to the equal potential lines on the maps.
- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.

  Plume maps: Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.

4.4 Reporting

The effectiveness of the corrective action program is reported twice each year as required by WAC 173-303-645(11)(g). Results from this monitoring plan are reported in both the semiannual corrective action groundwater report and the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

In accordance with WAC 173-303-645(11)(h), if it is determined by DOE that the corrective action program no longer satisfies the requirements of the corrective action program under WAC 173-303-645(11), an application for a permit modification to make any appropriate changes to the program will be submitted within 45 days.

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Appendix A

Quality Assurance Project Plan

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Terms

DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
DUP	duplicate (laboratory)
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
S&GRP	Soil and Groundwater Remediation Project
SAF	Sampling Authorization Form
SMR	Sample Management and Reporting
SPLIT	field split

Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
Tri-Party Agreement Action Plan	*Hanford Federal Facility Agreement and Consent Order Action Plan* (Ecology et al., 1989b)
TSD	treatment, storage, and disposal

A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan) require the QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal (TSD) units, as well as for past-practice processes. This QAPjP also describes the applicable requirements and controls based on guidance provided in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following five chapters, which describe the quality requirements and controls applicable to the 183-H Solar Evaporation Basins groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Assessment and Oversight
- Chapter A5, Data Review and Usability
- Chapter A6, References

A2 Project Management

This chapter addresses the management approaches planned, project goals, and planned output documentation.

A2.1 Project/Task Organization

Project organization (regarding routine groundwater monitoring) is described in the following subsections and illustrated in Figure A-1.

A2.1.1 DOE-RL Manager

Hanford Site cleanup is the responsibility of U.S. Department of Energy (DOE)-Richland Operations Office (RL). The DOE-RL Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, *Resource Conservation and Recovery Act of 1976* (RCRA); *Atomic Energy Act of 1954*; and Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

A2.1.2 DOE-RL Project Lead

The DOE-RL Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to the DOE-RL management.

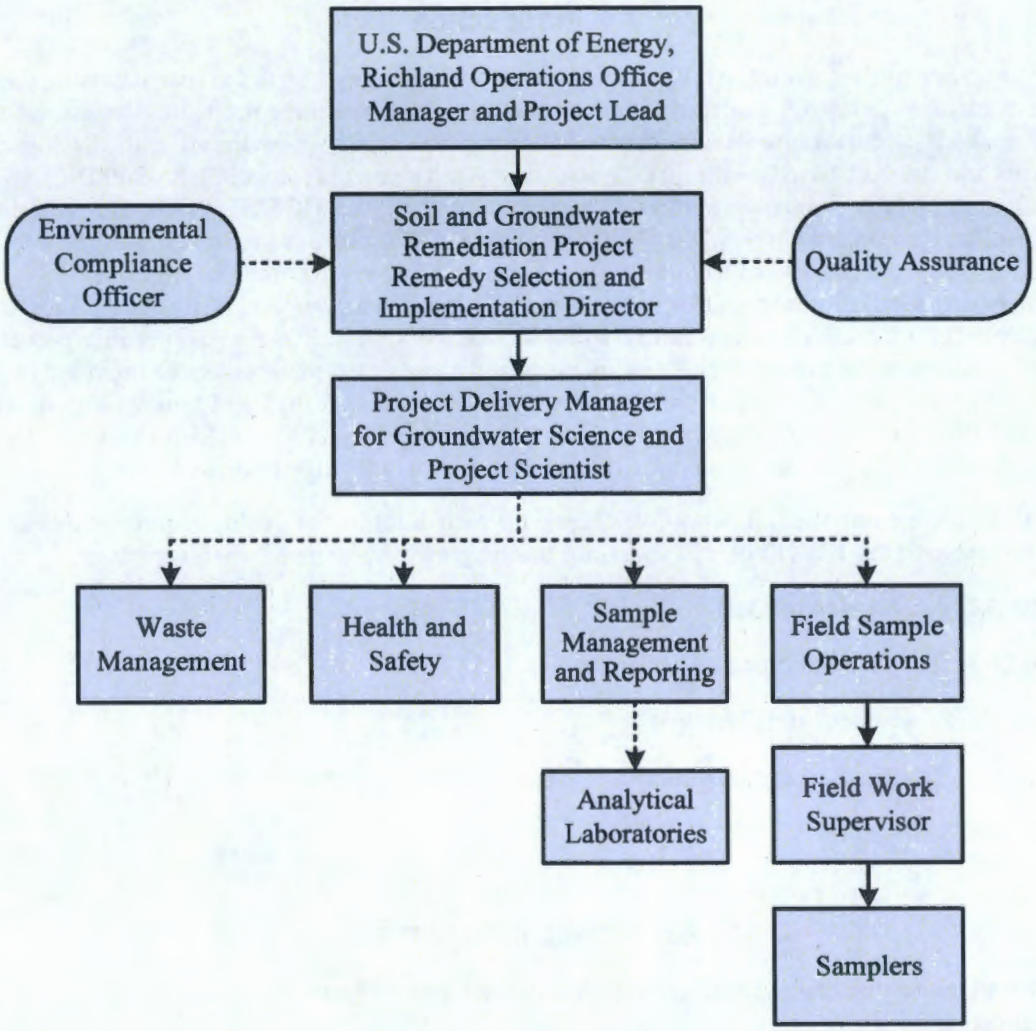

Figure A-1. Project Organization

A2.1.3 Soil and Groundwater Remediation Project Remedy Selection and Implementation Director

The Soil and Groundwater Remediation Project (S&GRP) Remedy Selection and Implementation Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Remedy Selection and Implementation Director also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

A2.1.4 Project Delivery Manager for Groundwater Science

The Project Delivery Manager for Groundwater Science is responsible for direct management of activities performed to meet TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with and reports to DOE-RL and primary contractor management regarding TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The Project Delivery Manager for Groundwater Science assigns scientists to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the Sampling Authorization Form (SAF), which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures it is appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. The SMR group is responsible for informing the Project Delivery Manager for Groundwater Science of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

FSO is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the nuclear chemical operators (samplers), who collect groundwater samples in accordance with this groundwater monitoring plan and corresponding standard procedures and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect amples in accordance with sampling documentation. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazardsnvironment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project and overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents, including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

A2.1.8 Environmental Compliance Officer

The ECO provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A2.1.9 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or internal primary contractor work requirements.

A2.1.10 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements, to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A2.1.11 Analytical Laboratories

The analytical laboratories analyze samples in accordance with established procedures and the requirements of this plan, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Statements of work flow down quality requirements consistent with the HASQARD (DOE/RL-98-68). The laboratories are evaluated under the DOE Consolidated Audit Program and must be accredited by the Washington State Department of Ecology (Ecology) for the analyses performed for S&GRP.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste,* Part II, Condition II.F, which specifies groundwater monitoring under WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units," for final status facilities. More specific information on the activities to satisfy the requirements is provided in the main text of this monitoring plan in Chapter 1 and Sections 2.7, 3.1, 3.2, 3.3, 3.4, 3.5, and 4.2. Background information on monitoring is also provided in the main text (Sections 2.2, 2.5, and 3.6).

A2.3 Project/Task Description

The focus of this plan is to monitor for dangerous waste in accordance with WAC 173-303-645(11), evaluate the well network, and interpret analytical results. The dangerous waste and field parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main text (Chapter 3). Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the monitoring plan. In support of this objective, data descriptors known as data quality indicators (DQIs) are used to help determine the acceptability and usefulness of the data to the user. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These DQIs are defined for the purposes of this document in Table A-1.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or re-measurement. • Qualify the data before use.
Accuracy (laboratory control samples, and matrix spikes)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include standard recoveries, laboratory control samples, and spiked samples.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or re-measurement.
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
			• Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data quality assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/ acceptance criteria).	If data set does not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, field transfer blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media. • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
	Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	known amount of contaminant spiked into a sample (matrix spike).	• Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V, as amended.*

a. Acceptance criteria for QC elements are provided in Table A-5.

b. For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QC = quality control

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated during the data quality assessment (DQA) process (Section A5.3).

A2.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, "Personnel Training." The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable *Code of Federal Regulations* and *Washington Administrative Code* requirements. Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up-to-date prior to performing any fieldwork.

A2.6 Documents and Records

The Project Delivery Manager for Groundwater Science (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Version control is maintained by the administrative document control process. Table A-2 defines the types of changes that may affect the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Elements of the monitoring plan that are required by WAC 173-303-645 (e.g., water-level measurements will be collected each time a sample is obtained) cannot be changed.

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Temporary addition of wells or site-specific constituents, or increased sampling frequency that does not affect the requirements of WAC 173-303-645.	Project Delivery Manager for Groundwater Science approves temporary change; provides informal notification to DOE-RL.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan that impacts the corrective action monitoring requirements of WAC 173-303-645, including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of indicator parameters, and loss of samples in transit.	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL. DOE-RL provides informal notification to Ecology as appropriate.	Annual Hanford Site RCRA groundwater monitoring report
Planned change to groundwater monitoring activities, that impacts the corrective action monitoring requirements of WAC 173-303-645, including addition or deletion of site-specific constituents, change of	Project Delivery Manager for Groundwater Science obtains DOE-RL approval; revise	Revised groundwater monitoring plan and modification to Hanford Facility RCRA Permit

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
sampling frequency for site-specific constituents, or changes to well network.	monitoring plan as appropriate.	
Anticipated unavoidable changes.	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report Permanent changes require revised RCRA groundwater monitoring plan and modification to Hanford Facility RCRA Permit

References:

Hanford Facility RCRA Permit (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*).

WAC 173-303-645, "Dangerous Waste Regulations," "Releases from Regulated Units."

DOE-RL = U.S. Department of Energy, Richland Operations Office

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

SMR = Sample Management and Reporting

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The FWS, SMR, and any field crew supervisors are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the groundwater monitoring plan. The SMR group will ensure that any deviations from the plan are reflected in revised field sampling documents for the samplers and analytical laboratory. The FWS or appropriate field crew supervisors will ensure that deviations from the plan or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The Project Delivery Manager for Groundwater Science, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The Project Delivery Manager for Groundwater Science is also responsible for ensuring that project files are setup, as appropriate, and/or maintained. The project files will contain project records or references to their storage locations. Project files generally include, as appropriate, the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports

- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract

The following records are managed and maintained by SMR personnel:

- Completed field sampling logbooks
- Groundwater sample reports and field sample reports
- Completed chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data "case file purges" (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information
- Training records for employees, as they relate to analytical methods.
- Laboratory state accreditation records
- Laboratory audit records

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein. Records of analyses required by WAC 173-303-645(11), as well as associated groundwater surface elevations required by WAC 173-303-645(8) are to be maintained throughout the active life of a facility and post-closure care period.

The results of corrective action groundwater monitoring are reported twice each year as required by WAC 173-303-645(11). Groundwater monitoring results are also presented in the annual Hanford Site RCRA groundwater monitoring reports (e.g. DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition to ensure that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

A3.1 Analytical Method Requirements

Analytical method requirements for samples collected are presented in Table A-3. Updated U.S. Environmental Protection Agency (EPA) methods may be substituted for the analytical methods identified in Table A-3.

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L)
Dangerous Waste Constituents (µg/L)		
Metals		
Total Chromium (filtered)	EPA 200.8 or SW-846 6020 – ICP/MS	10
Anions		
Nitrate[c]	EPA/600 Method 300.0	250
Site-Specific Measurements		
Field Parameters		
Dissolved Oxygen	Field measurement Instrument/meter	N/A
pH		N/A
Specific Conductance		N/A
Temperature		N/A
Turbidity		N/A

Note: Analytical methods and highest allowable PQLs provided in this table do not represent EPA requirements but are intended solely as guidance.

a. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*. Equivalent methods may be substituted.

b. For purposes of this groundwater monitoring plan, the highest allowable PQL is interchangeable with the lower limit of quantitation, which is the lowest level that can be routinely quantified and reported by a laboratory. The highest allowable PQLs are not to be exceeded and are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower than required contractually. Method detection limits are three to five times lower than quantitation limits.

c. For general chemistry analyses, dilutions for certain ion chromatography constituents may be necessary, potentially raising the PQL above the limits established in this table. In circumstances where the PQL is critical to a project, the SMR group will negotiate with the project scientist regarding project-specific requirements.

EPA = U.S. Environmental Protection Agency N/A = not applicable

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L)

ICP-MS = inductively coupled plasma-mass spectrometry PQL = practical quantitation limit

A3.2 Field Analytical Methods

Field screening and survey data used will be measured in accordance with HASQARD (DOE/RL-96-68) requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Table A-3 provides the parameters (if any) identified for field measurements. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

QC requirements specified in the plan must be followed in the field and analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in HEIS, as appropriate.

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field Duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed When needed, the minimum is one for every analytical method, for analyses performed.	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	One in 20 well trips	Cross-contamination from containers or transportation
Equipment Blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blank is not required; otherwise, one for every 20 samples.[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical QC[b]		
Laboratory Sample Duplicates	One per analytical batch[c]	Laboratory reproducibility and precision

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Matrix Spikes	One per analytical batch[c]	Matrix effect/laboratory accuracy
Matrix Spike Duplicates	One per analytical batch[c]	Laboratory accuracy and precision
Laboratory Control Samples	One per analytical batch[c]	Laboratory accuracy
Method Blanks	One per analytical batch[c]	Laboratory contamination

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. For portable pumps, equipment blanks are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

b. Batching across projects is allowed for similar matrices (e.g., all Hanford groundwater).

c. Unless not required by, or different frequency is called out in, laboratory analysis methods.

EPA = U.S. Environmental Protection Agency

QC = quality control

1

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
Metals			
Inductively coupled plasma-mass spectrometry metals (total chromium [filtered])	MB	<MDL <5% Sample concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[a]
	DUP[b]/MSD[c]	≤20% RPD	Review Data[a]
	MS/MSD[c]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[b]	Review Data[a]
Anions			
Anions by ion chromatography (nitrate)	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[a]
	DUP[b]/MSD[c]	≤20% RPD	Review Data[a]

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
	MS/MSD[c]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[b]	Review Data[a]

Notes:

The information in this table does not represent EPA requirements but is intended solely as guidance. The table is consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*; and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document.*

This table only applies to laboratory analyses. Specific conductance, pH, dissolved oxygen, temperature, and turbidity are not listed as they are measured in the field.

a. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect (Y flag), failed field QC (Q flag), or rejected (R flag).

b. Applies when at least one result is greater than the laboratory PQL (chemical analyses).

c. Either a DUP or a MSD is to be analyzed to determine measurement precision.

DUP = laboratory sample duplicate
EB = equipment blank
EPA = U.S. Environmental Protection Agency
FTB = full trip blank
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference

Data Flags:

C = possible laboratory contamination: analyte was detected in the associated method blank
N = result may be biased: associated matrix spike result was outside the acceptance limits
Q = problem with associated field QC blank: results were out of limits

A3.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure that reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and two types of field blanks (full trip blanks [FTBs] and equipment blanks [EBs]). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described below:

Field duplicates: independent samples collected as close as possible to the same time and same location as the scheduled sample, and intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field splits (SPLITs): two samples collected as close as possible to the same time and same location and are intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

Full trip blanks (FTBs): bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity reagent water[1], and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Equipment blanks (EBs): Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with samples from the associated sampling event. EB samples will be analyzed for the same constituents as samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process and these samples are not required for disposable sampling equipment.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), laboratory control samples (LCSs), and method blanks (MBs). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC check and their typical frequencies are listed in Table A-4. Acceptance criteria are shown in Table A-5. Descriptions of the various types of laboratory QC samples are as follows:

Laboratory sample duplicate (DUP): an intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

Matrix spike (MS): an aliquot of a sample spiked with a known concentration of target analyte(s). MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate (MSD): a replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

Laboratory control sample (LCS): a control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.

Method blank (MB): an analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical procedure and is used to quantify contamination resulting from the analytical process.

Laboratories are required to analyze samples within the holding times specified in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by

[1] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

volatilization, decomposition, or other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an "H."

Table A-6. Holding Time Guidelines for Laboratory Analyses

Constituent/Parameter	Holding Time
Total chromium (filtered) by inductively coupled plasma-mass spectrometry	6 months
Anions by ion chromatography (nitrate)	48 hours

Notes:

Information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Field parameters, pH, specific conductance, temperature, dissolved oxygen, and turbidity, are not listed as they are measured in the field.

A3.4 Measurement Equipment

Each user of the measuring equipment is responsible to ensure that equipment is functioning as expected, properly handled, and properly calibrated at required frequencies in accordance with methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded in accordance with approved methods. Field screening instruments will be used, maintained, and calibrated in accordance with manufacturer specifications and other approved methods.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or should have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with applicable Hanford Site requirements.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with test methods in SW-846 and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply

with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

A3.8 Nondirect Measurements

Data obtained from sources, such as computer databases, programs, literature files, and historical databases, will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

A3.9 Data Management

The SMR group, in coordination with the Project Delivery Manager for Groundwater Science, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods. Records of data analyses and groundwater surface elevations are maintained as required by WAC 173-303-645(8)(j).

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group through an established process. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the Project Delivery Manager for Groundwater Science. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

A4 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this plan, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project's line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the Project Delivery Manager for Groundwater Science.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with laboratory QA plans. The SMR group oversees offsite analytical laboratories and verifies that laboratories are qualified to perform Hanford Site analytical work.

A4.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by self-assessments, corrective actions from ECOs, and findings from QA assessments and surveillances. Issues reported by the laboratories are communicated to the SMR group, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the Project Delivery Manager for Groundwater Science.

A5 Data Review and Usability

This chapter addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A5.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met. Furthermore, a review of QC data is used to determine whether analyses have met the data quality requirements specified in this plan.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results also will be reviewed to ensure that they are usable.

The project scientist, assigned by the Project Delivery Manager for Groundwater Science, will perform a data review to help determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in submittal of a request for data review on questionable data. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the request for data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

A5.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science and under the direction of the SMR group. It is based on the results of the QC samples for an individual network, discussions with the project scientist, and discussions with the laboratory services manager. If defined as appropriate, data validation (third party) will be performed at a minimum frequency of 5 percent and be based on EPA functional guidelines.

A5.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data quality needs. For routine groundwater monitoring performed through this groundwater monitoring plan, the DQA is captured in the DQA appendix associated with the annual Hanford Site RCRA groundwater report (e.g. DOE/RL-2016-12), which evaluates field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of the Project Delivery Manager for Groundwater Science and documented in a report overseen by the SMR group.

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Appendix B

Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
gpm	gallons per minute
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
NTU	nephelometric turbidity unit
QA	quality assurance
QC	quality control
SMR	Sample Management and Reporting

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B1 Introduction

Groundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* and implemented in WAC 173-303, "Dangerous Waste Regulations," has been conducted since the mid-1980's. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken; equipment and its use; cleaning and decontamination; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B provide the sampling and analysis essentials necessary for the groundwater monitoring plan: sample collection, sample holding times, chain–of-custody control, analytical procedures, and field and laboratory quality assurance (QA)/quality control (QC).

This appendix provides more specific elements of the sampling protocols and techniques used for the groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, constituents to be analyzed, and sampling frequency for the groundwater monitoring at the 183-H Solar Evaporation Basins.

B2 Sampling Methods

Sampling may include, but is not limited to, the following methods:

- Field screening measurements
- Groundwater sampling
- Water level measurements

Groundwater samples will be collected in accordance with to the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (32.3°F)
- **Conductivity** – two consecutive measurements agree within 10 percent of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist's recommendation)

Dissolved oxygen will also be measured in the field in this groundwater monitoring plan. Dissolved oxygen is not required to be stable prior to sample collection.

Unless special requirements are requested from project scientists, wells are typically purged using the equivalent volume as that of three borehole diameters multiplied by the length of the saturated portion of the well screen. Stable field readings are also required as specified above. The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gallons per minute [gpm]), depending on the pump, although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged for a minimum of 1 hour and are then sampled once stable field readings are obtained.

Field measurements (except for turbidity) are obtained using a flow-through cell. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean, stainless-steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, conductivity, and

dissolved oxygen. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean, stainless-steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g., metals) both filtered and unfiltered samples are collected. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline, disposable 0.45 μm filter is used.

Typically, three traditional types (i.e., Grundfos[1], Hydrostar[2], and submersible electrical pumps) of environmental grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support pumping of samples because of low yield or the physical characteristics of the well. In these cases, a grab sample may be obtained. In cases where there is not sufficient yield, purgewater activities are not performed.

Low-purge-volume sampling methodology for the collection of groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically on the order of 0.1 to 0.5 L/min (0.26 to 0.13 gpm). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low-purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

For certain types of samples, preservatives are required. Preservatives, based on the analytical methods used, are added to the collection bottles before their use in the field. Samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, sampling associated with this groundwater monitoring plan will be performed in accordance with the requirements of DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), pertaining to sample collection, collection equipment, and sample handling.

Sample holding-time requirements are specified for groundwater samples in Appendix A, Table A-6. These requirements are in accordance with the analytical method specified in Appendix A, Table A-3. The container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding-time restrictions.

Holding time is the maximum allowable period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater;* and SW-846, *Test Methods for Evaluating Solid Waste,*

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[1] Grundfos® is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.

[2] Hydrostar® is a registered trademark of KYB Corporation, Tokyo, Japan.

Physical/Chemical Methods, Third Edition; Final Update V. Recommended holding times are also provided in HASQARD (DOE/RL-96-68) and in applicable laboratory contracts.

B2.1 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each specific sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment and pumps is performed using high-purity water[3] in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the equipment is washed in a phosphate-free detergent solution, followed by rinsing with water in three sequential containers. After the third water rinse, equipment that is stainless-steel or glass is rinsed in a 1M nitric acid solution (pH less than 2). Equipment is then rinsed with water in three sequential containers (the water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at 50 degrees C (122 degrees F) for items that are not metal or glass or at 100 degrees C (212 degrees F) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is enclosed in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. The pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with water. The pump is submerged in water and 30.3 L (8 gal) of water is pumped through the unit and disposed. The pump is removed from the water and the intake and housing are covered with plastic sleeving. The cleaning is documented on a tag that is affixed to the pump, and the tag will include the following information:

- Date pump cleaned
- Pump identification

[3] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

- Comments
- Signature of person performing decontamination

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater surface elevation at each monitoring well is required by WAC 173-303-645(8)(f), "Releases from Regulated Units." Using a calibrated depth measurement tape, the depth to water is recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.), the final determined measurement is recorded along with the date and time for the specific event (e.g., sampling or annual water level measurements). The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks or data forms are required for field activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor (FWS), cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks or on data forms is as follows:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were conducted reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation, if any, of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag number, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.

- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

B3.1 Corrective Actions and Deviations for Sampling Activities

The Project Delivery Manager for Groundwater Science, FWS, appropriate field crew supervisors, and Sample Management and Reporting (SMR) personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The Project Delivery Manager for Groundwater Science, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Appendix A, Table A-2.

B4 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. The results from all instrument calibration activities are recorded in accordance with the HASQARD requirements (DOE/RL-96-68).

Field instrumentation calibration and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system.
- At the frequency recommended by the manufacturer or methods, or as required by regulations.
- Upon failure to meet specified QC criteria.
- Daily calibration checks will be performed and documented for each instrument used. These checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data. Analysis times will be sufficient to establish detection efficiency and resolution.
- Using standards used for calibration that are traceable to a nationally recognized standard agency source or measurement system. Manufacturer's recommendations for storage and handling of standards (if any) will be followed.

B5 Sample Handling

Sample handling and transfer will be in accordance with established methods to preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that

sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and analytical database is used to track samples from the point of collection through the laboratory analysis process.

B5.1 Containers

Samples shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the laboratory lot number of the bottles used in sample collection. When commercially pre-cleaned containers are used in the field, the name of the manufacturer, lot identification, and certification shall be retained for documentation.

Containers shall be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions shall be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody will be maintained in accordance with existing protocols to ensure that sample integrity is maintained throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, new and previous custodians will sign the record and note the date and time. The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.

The following minimum information is required on a completed chain-of-custody form:

- Project name
- Collectors' names
- Unique sample number
- Date and time of collection
- Matrix

- Preservatives
- Chain of possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Shipped-to information (i.e., analytical laboratory performing the analysis)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group; so special direction for analysis can be provided to the laboratory if deemed necessary.

B5.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway."[4] Carrier-specific requirements defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*, shall also be used when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*. For waste designation purposes, wells listed in Table 3-2 in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required.

Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater and decontamination fluids will be collected and managed in accordance with DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*; and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*. Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements.

Packaging and labeling during waste storage and transportation will meet WAC 173-303 and DOT requirements, as appropriate. Packaging exceptions to DOT requirements may be used for onsite waste

[4] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

shipments if documented as such and if the packaging provides an equivalent degree of safety during transportation.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities.

B7 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, "Worker Safety and Health Program," which incorporates the standards of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response"; 10 CFR 830, "Nuclear Safety Management"; and 10 CFR 835, "Occupational Radiation Protection." The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control; and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

B8 References

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49 CFR 171, "General Information, Regulations, and Definitions."

49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans."

49 CFR 173, "Shippers-General Requirements for Shipments and Packagings."

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Appendix C

Well Construction

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Tables

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme C-1

Table C-2. Sampling Interval Information for Wells within the 183-H Solar Evaporation Basins Network C-1

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C1 Introduction

This appendix provides the following information for the 183-H Solar Evaporation Basins groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be monitored (the portion of the aquifer that is located at the well screen or perforated casing) (Table C-1)

The following sampling interval information, as shown in Table C-2:

- Elevation at top of the screen or perforated interval
- Elevation at the bottom of the screen or perforated interval
- Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)

Figures C-1 through C-5 provide the well construction and completion summary for wells 199-H4-8, 199-H4-84, 199-H4-85, 199-H4-88, and 199-H4-89.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	**Top of Unconfined.** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-2. Sampling Interval Information for Wells within the 183-H Solar Evaporation Basins Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft]) NAVD88	Elevation Bottom of Open Interval (m [ft]) NAVD88	Open Interval Length (m [ft])
199-H4-8	TU	117.0 (383.9)	114.0 (374.0)	3.0 (9.9)
199-H4-84	TU	117.2 (384.5)	114.1 (374.3)	3.1 (10.2)
199-H4-85	TU	119.7 (392.7)	113.6 (372.7)	6.1 (20.0)
199-H4-88	TU	119.3 (391.1)	113.2 (371.1)	6.1 (20.0)
199-H4-89	TU	118.6 (388.9)	114.1 (374.1)	4.6 (15.0)

Reference: NAVD88, *North American Vertical Datum of 1988*.

Note: See Table 3-2 in main text for depth of remaining water column.

TU = Top of Unconfined, as described in Table C-1

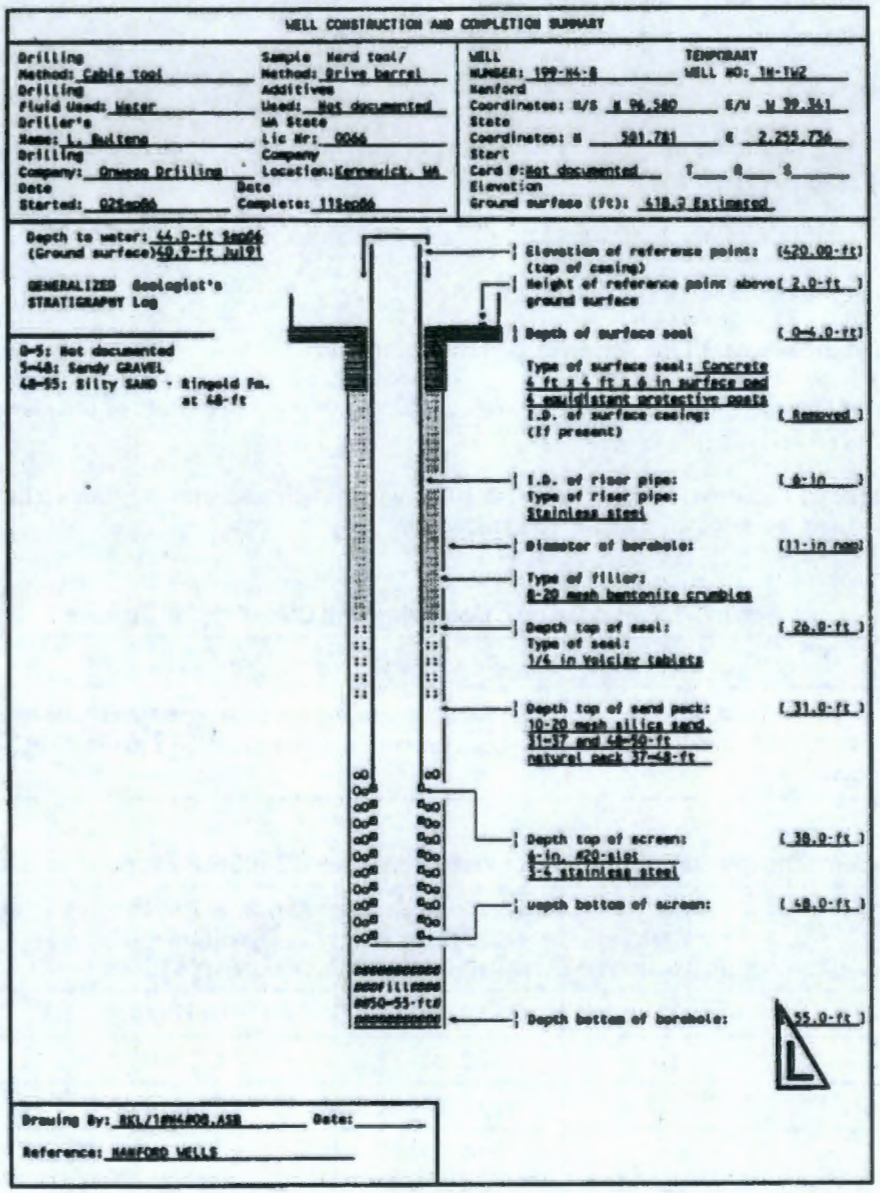

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Figure C-1. Well 199-H4-8 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 2-4-11	Page 1 of 1
		Finish Date: 2-16-11	
Well ID: C7880		Well Name 199-H4-84	
Location: N of D Reactor		Project: WCH Characterization Borehole	
Prepared by: C. Burnette	Date: 2-22-11	Reviewed by: L. D. Walker	Date: 3-2-11
Signature:		Signature:	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Ground surface circular concrete seal with brass well marker: 0-2.5 ft bgs Well monument 0.0-1.0 ft bgs		0		0-19' Sandy Gravel (sG) 0-19 ft bgs was backfill from previous remediation.
CW 3/8/11 4-in dia SCH 40 PVC blank 0.42-37.65 ft bgs		10		
#8 bentonite crumbles: 2.5-33.5 ft bgs		20		19-41 ft. bgs Silty Sandy Gravel (msG)
Temporary Casing: 10 5/8-in Carbon Steel: 0-46.2 ft bgs				
CW 3/8/11 4-in dia. 20 slot PVC Screen 37.65-47.65 ft bgs		30		
CW 3-8-11 mesh 10-20 slot silica sand 33.5-48.6 ft bgs bgs				
PVC cap 47.65-48.0 ft bgs		40		41-48.6 ft bgs Sandy Gravel (sG) Static water at 41.5 ft bgs. Tagged on 2-9-11 T.D 48.6 ft bgs Tagged on 2-9-11
Note: All temporay casing was removed during well construction. Centralizers were place just above and below the screen.		50		

Figure C-2. Well 199-H4-84 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 3/05/2013 Finish Date: 3/14/2013	Page 1 of 1
Well ID: C8723		Well Name: 199-H4-85	
Location: 100-H, North of Reactor on H Ave.		Project: WCH Replacement Wells at 100-D/H	
Prepared by: Tessa Clark	Date: 3/18/2013	Reviewed by: L. Craig Swanson	Date: 5/29/13
Signature:		Signature:	

CONSTRUCTION DATA

Description

Surface Completion: 4'x4'x6" Concrete Pad w/brass survey marker and 8 5/8" protective monument (3 ft ags).

Concrete Surface Seal:
Type I/II Portland Cement
0.0' bgs - 10.2' bgs.

Permanent Well:
6 5/8" OD Stainless Steel Blank
2.0' ags - 27.39' bgs

6 5/8" OD Stainless Steel 0.040 slot Screen
27.39' bgs - 47.29 ' bgs

6 5/8" Stainless Steel Sump w/end cap
47.29' bgs - 52.40' bgs

#8 Granular Bentonite Crumbles:
10.2' bgs - 18.9' bgs

1/4" Uncoated Bentonite Pellets:
18.9' bgs - 22.5' bgs

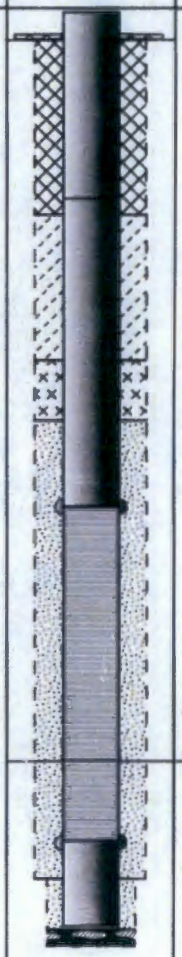
10-20 Colorado Silica Sand Pack:
22.5' bgs - 52.5' bgs

Natural Backfill:
52.5' bgs - 53.5' bgs

All temporary 10 3/4" OD casing completely removed from ground (3/13/2013).

bgs = below ground surface
ags = above ground surface

Diagram

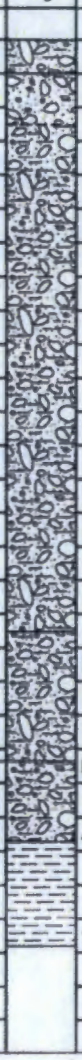


Depth in Feet

0, 10, 20, 30, 40, 50

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description

0 - 2: Silty Sandy Gravel, msG

2 - 5: Sandy Gravel, sG

5 - 35: Silty Sandy Gravel, msG

35 - 47.5: Silty Sandy Gravel, msG

DTW = 42.6'bgs (3/11/2013)

47.5 - 53.5: Silt, M

TD = 53.5' bgs (3/7/2013)

Figure C-3. Well 199-H4-85 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 3/14/16 Finish Date: 3/23/16	Page 1 of 1
Well ID: C8734		Well Name: 199-H4-88	
Location: 0.2 miles NNE of H reactor		Project: HR-3 Replacement Wells	
Prepared by: Julie Johanson	Date: 4/6/16	Reviewed by: J.D. MEHRER Environmental Scientist	Date: 4-13-16
Signature:		Signature:	

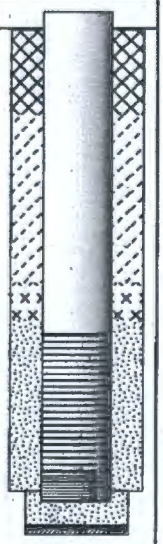
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Surface Completion: 4'x4'x6" Concrete Pad with brass survey marker and 6 9/16" protective monument (3.00' ags)		0		0-16: Sandy Gravel (sG)
Well Completion material: High Strength Concrete 0.0' bgs - 0.65' bgs		20		
Type I/II Portland Cement 0.65' bgs - 10.08' bgs				
Granular Bentonite 3/8" 10.08' bgs - 30.08' bgs				
3/8" Bentonite Pellets 30.08 bgs - 34.29' bgs		40		
10-20 Colorado Silica Sand 34.29' bgs - 52.91' bgs				
20-40 Colorado Silica Sand 52.91' bgs - 59.17' bgs				53-59.90: Silt (M) [RUM]
Natural Fill 59.17' bgs - 59.90' bgs		60		
Permanent Well: 6" ID Stainless Steel Blank 2.01' ags - 38.00' bgs		80		
6" ID Stainless Steel 0.040 Slot Screen 38.00' bgs - 53.00' bgs				
6" ID Stainless Steel 0.006 Slot Screen w/Cap 53.00' bgs - 58.09' bgs		100		
All temporary casing completely removed from ground on 3/21/2016				
ags = above ground surface bgs = below ground surface				

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Figure C-4. Well 199-H4-88 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 1/27/16 Finish Date: 3/30/16	Page 1 of 1
Well ID: C8735		Well Name: ~~199-H4-87~~ 199-H4-89	
Location: S. of 100 H Pump & Treat		Project: HR-3 Replacement Wells	
Prepared by: Julie Johanson	Date: 4/6/16	Reviewed by: J.D. MEHRER ~~Environmental Scientist~~	Date: 4-13-16
Signature: Julie Johanson		Signature:	

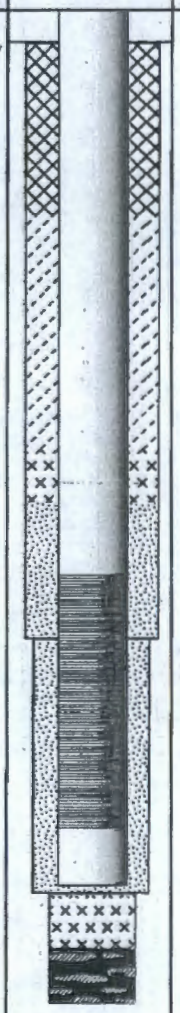
CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description
Surface Completion: 4'x4'x6" Concrete Pad with brass survey marker and 6 9/16" protective monument (3.00' ags)		0		0-15: Silty Sandy Gravel (msG)
Well Completion material: Type I/II Portland Cement 0.00' bgs - 10.10' bgs		10		
Granular Bentonite 3/8" 10.10' bgs - 24.02' bgs				15-29: Sandy Gravel (sG)
3/8" Bentonite Pellets 24.02 bgs - 27.10' bgs		20		
10-20 Colorado Silica Sand 27.10' bgs - 50.25' bgs				
3/8" Bentonite Pellets 50.25' bgs - 53.40' bgs				
Natural Fill 53.40' bgs - 56.60' bgs		30		29-35: Silty Gravel (mG)
Permanent Well: 6" ID Stainless Steel Blank 2.00' ags - 31.42' bgs				35-45: Sandy Gravel (sG)
6" ID Stainless Steel 0.040 Slot Screen 31.42' bgs - 46.37' bgs		40		
6" ID Stainless Steel Sump 46.37' bgs - 49.35' bgs				45-46: Silty Sand (mS) 46-56.60: Silt (M) [RUM]
All temporary casing completely removed from ground on 3/17/2016		50		
ags = above ground surface bgs = below ground surface				

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Figure C-5. Well 199-H4-89 Construction and Completion Summary

C2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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Appendix D

Dangerous Waste Corrective Action Monitoring Results

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D1 Introduction

This appendix presents the corrective action monitoring results of the 183-H Solar Evaporation Basins dangerous waste total chromium (collected as a filtered sample) in the groundwater monitoring well network. Results for hexavalent chromium (filtered) are also presented.

Corrective action monitoring of 183-H Solar Evaporation Basins commenced in 1997. The 183-H Solar Evaporation Basins concentration limits identified in Part VI, Post Closure Unit 2, of the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* are 48 µg/L for total chromium (filtered) and 45 mg/L for nitrate.

The 183-H Solar Evaporation Basins monitoring network has included a total of four wells since the corrective action monitoring period began in 1997. However, wells within the network have changed since 1997. Wells have been within the 183-H Solar Evaporation Basins network for the following durations:

- 199-H4-3 – 1997 to 2013
- 199-H4-7 – 1997 to 2005
- 199-H4-8 – 2005 to present
- 199-H4-12A – 1997 to present
- 199-H4-12C – 1997 to present
- 199-H4-84 – 2013 to present

Figures D-1 through D-6 present the results of total chromium (filtered) monitoring at 183-H Solar Evaporation Basin monitoring network wells during corrective action monitoring. The available hexavalent chromium (filtered) results during these periods are also included. Well 199-H4-85 was drilled in 2013 and is added to the monitoring network in this updated plan. Available sampling results for total chromium (filtered) and hexavalent chromium (filtered) at well 199-H4-85 are presented in Figure D-7. Figures D-8 through D-14 present results of nitrate monitoring for these wells during corrective action monitoring.

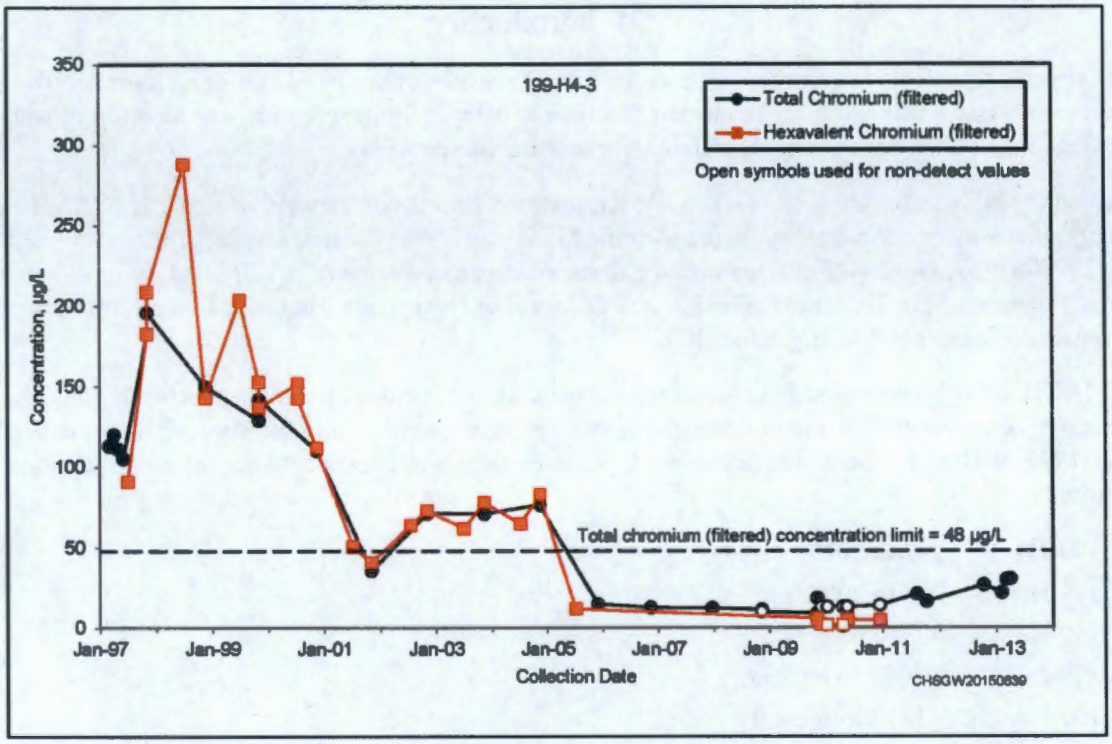

Figure D-1. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-3

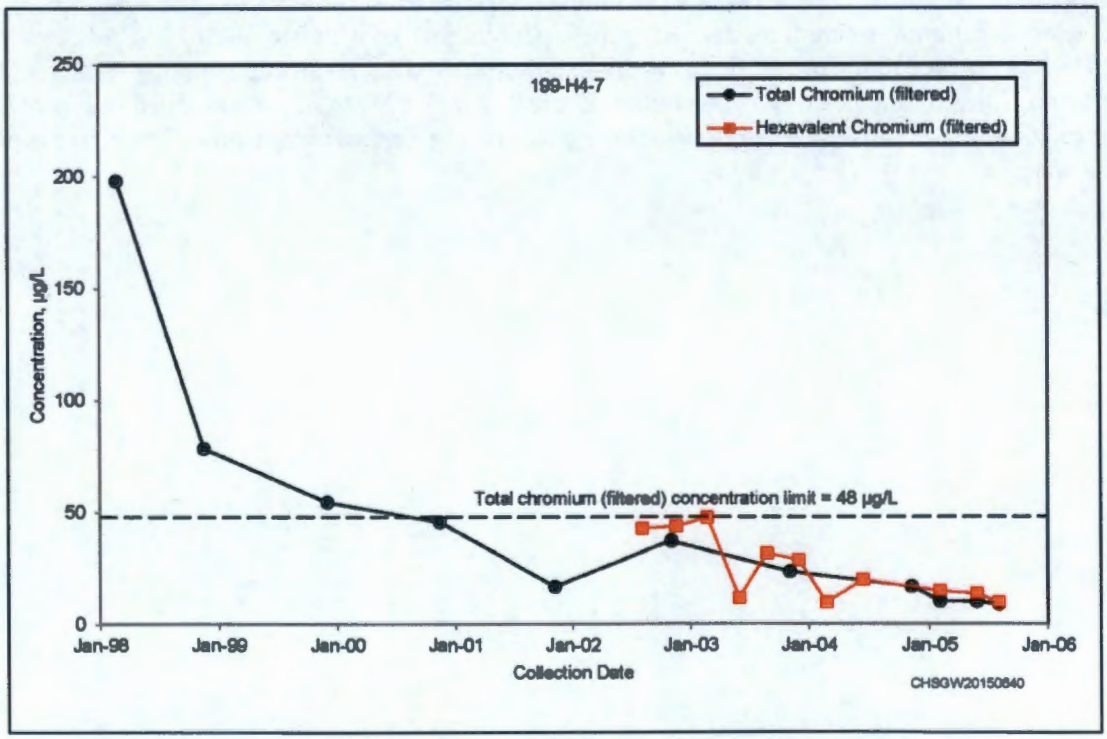

Figure D-2. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-7

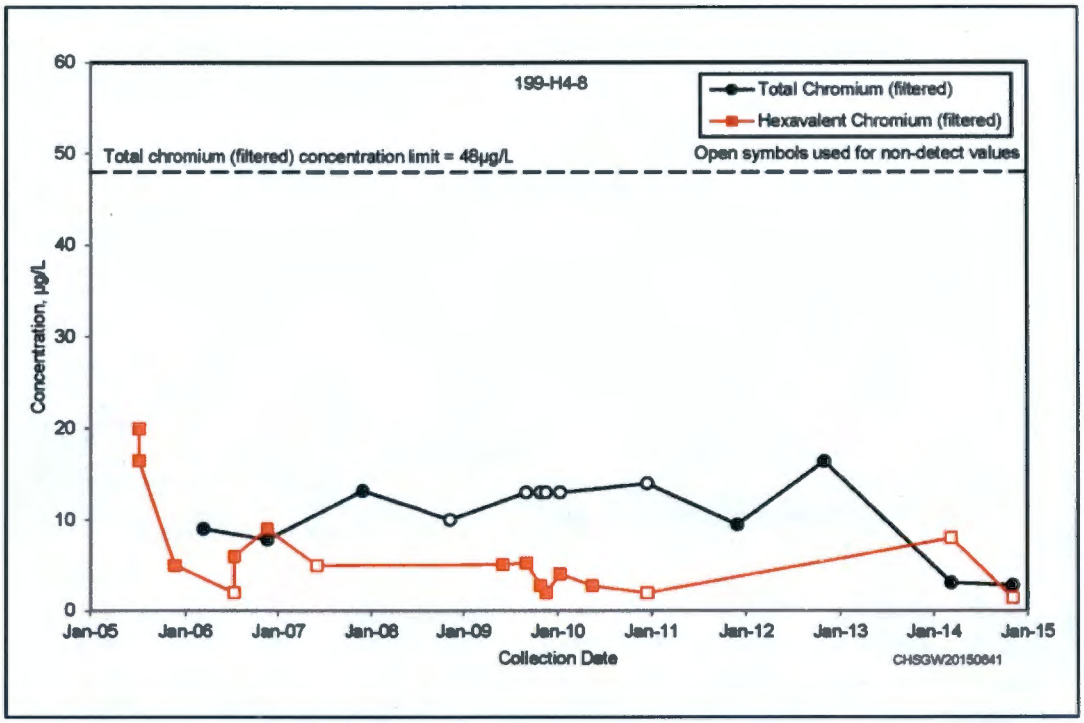

Figure D-3. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-8

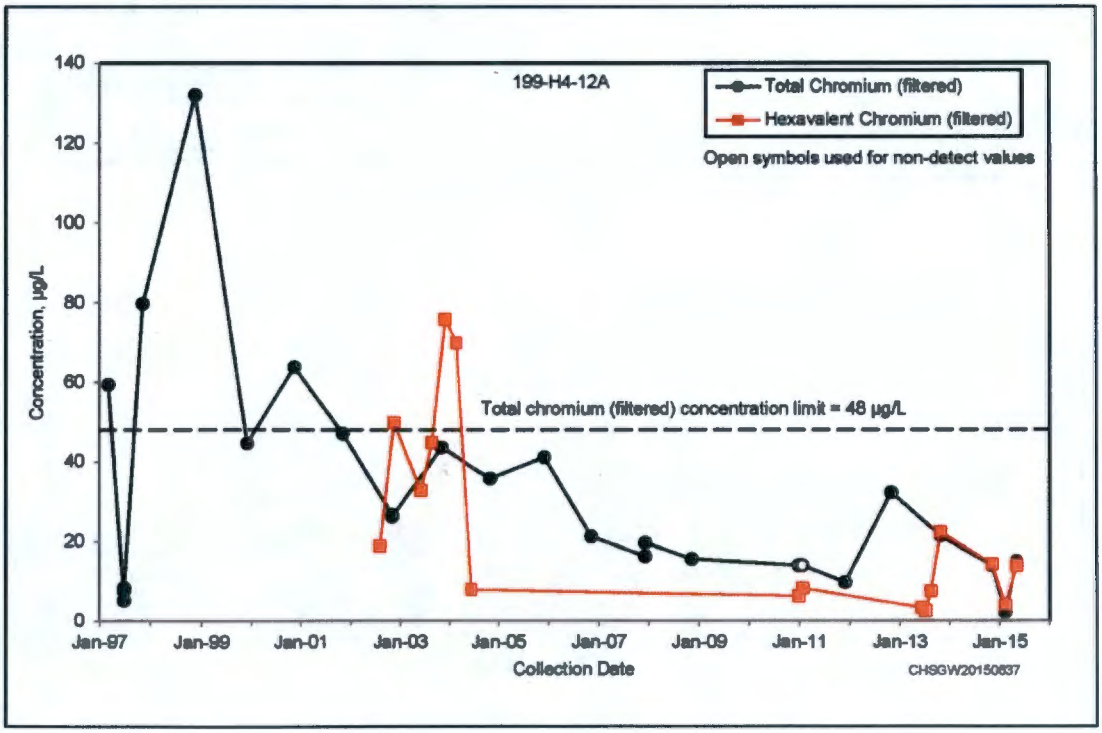

Figure D-4. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-12A

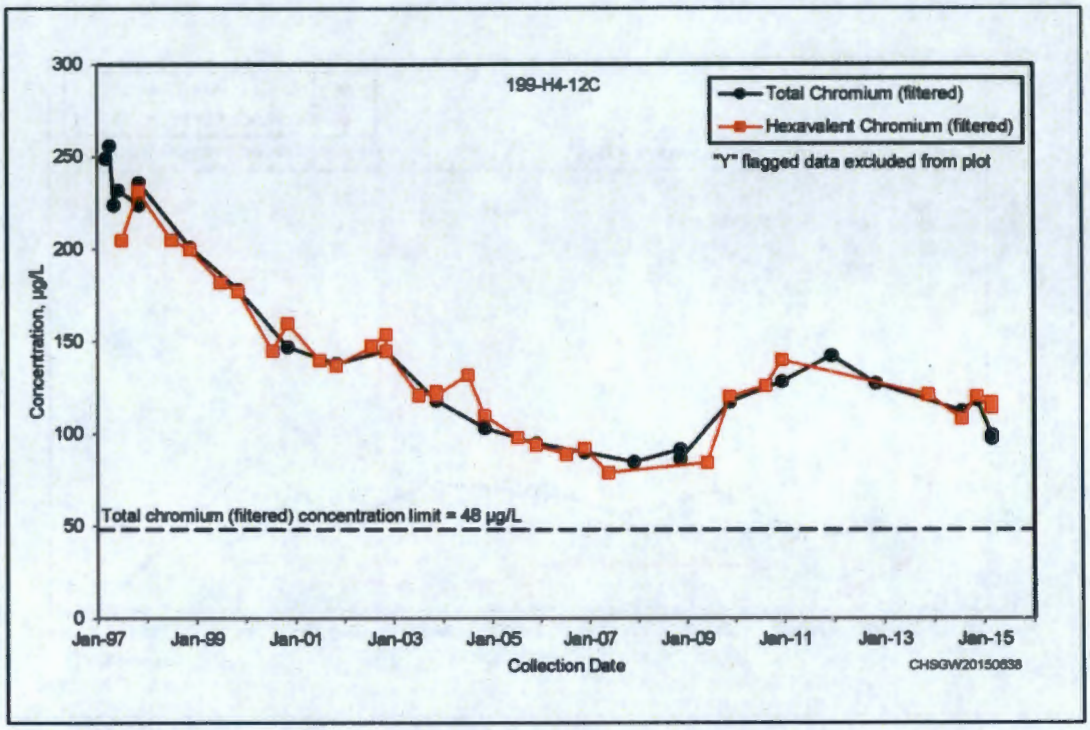

Figure D-5. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-12C

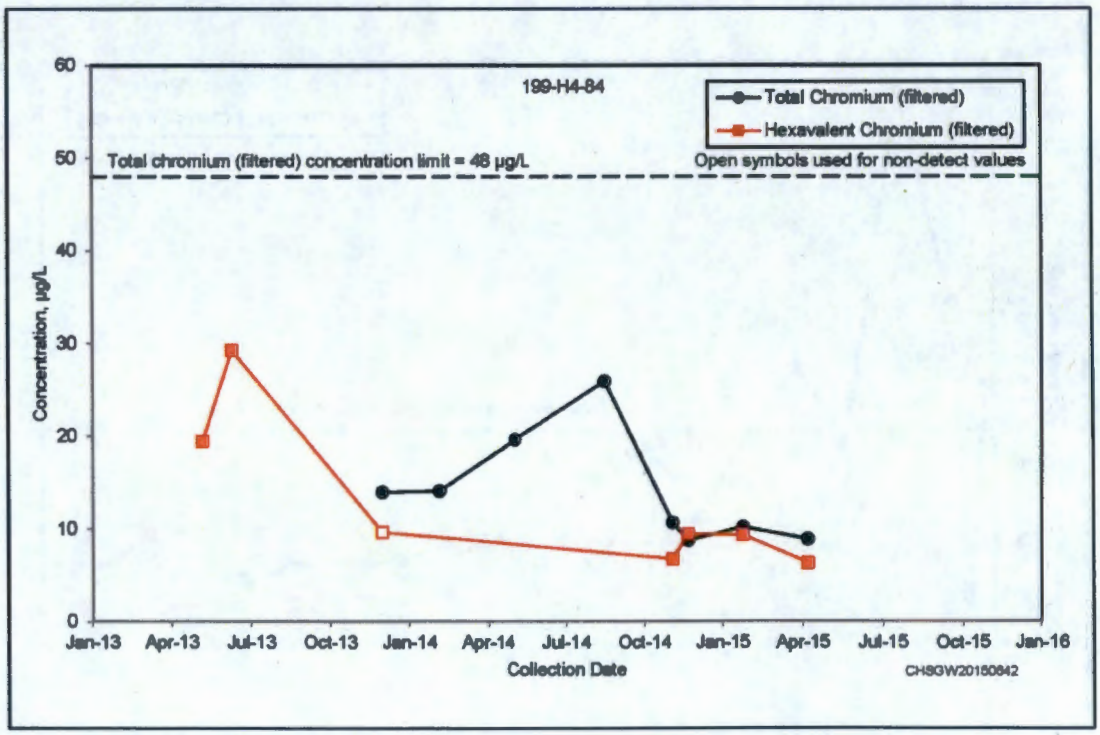

Figure D-6. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-84

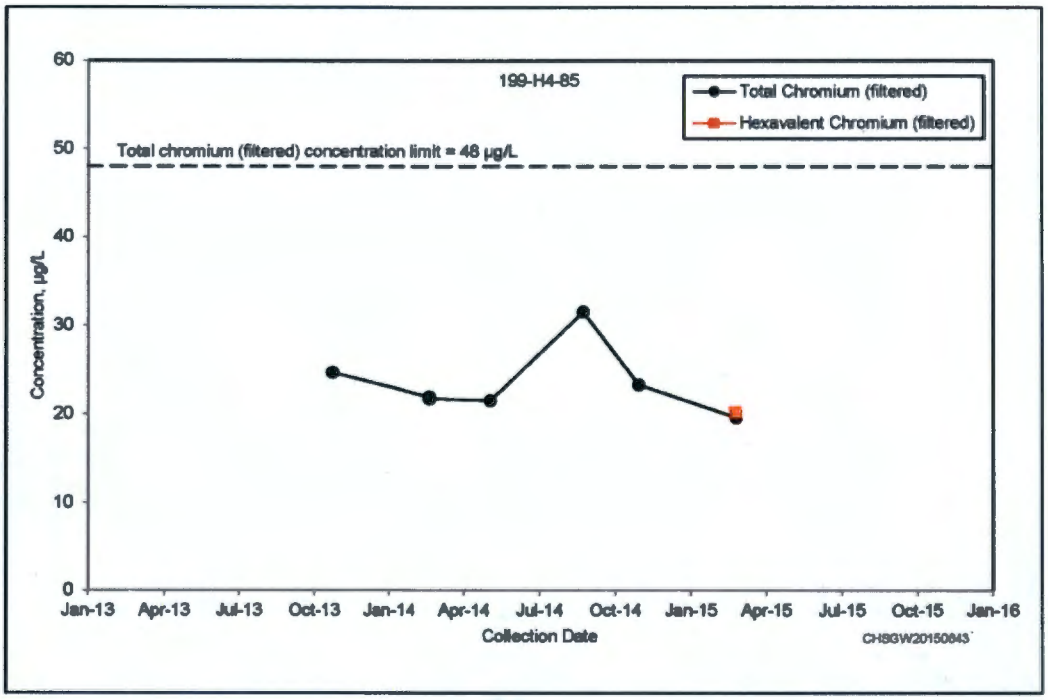

Figure D-7. Corrective Action Monitoring Results of Total Chromium (Filtered) and Hexavalent Chromium (Filtered) at Well 199-H4-85

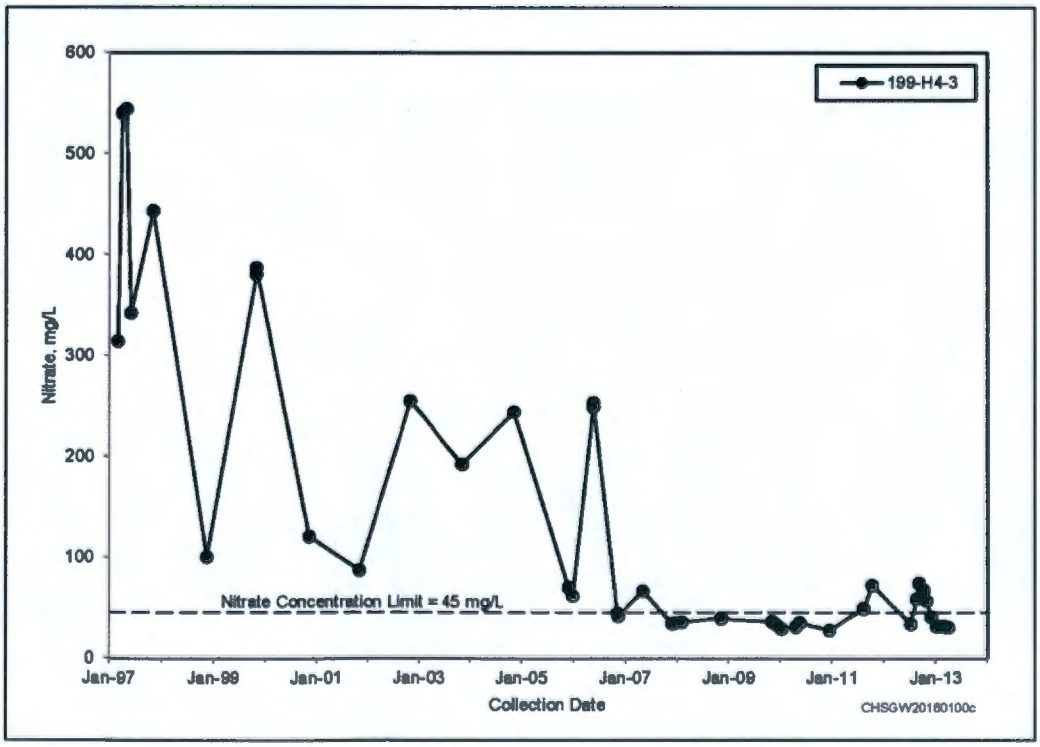

Figure D-8. Corrective Action Monitoring Results of Nitrate at Well 199-H4-3

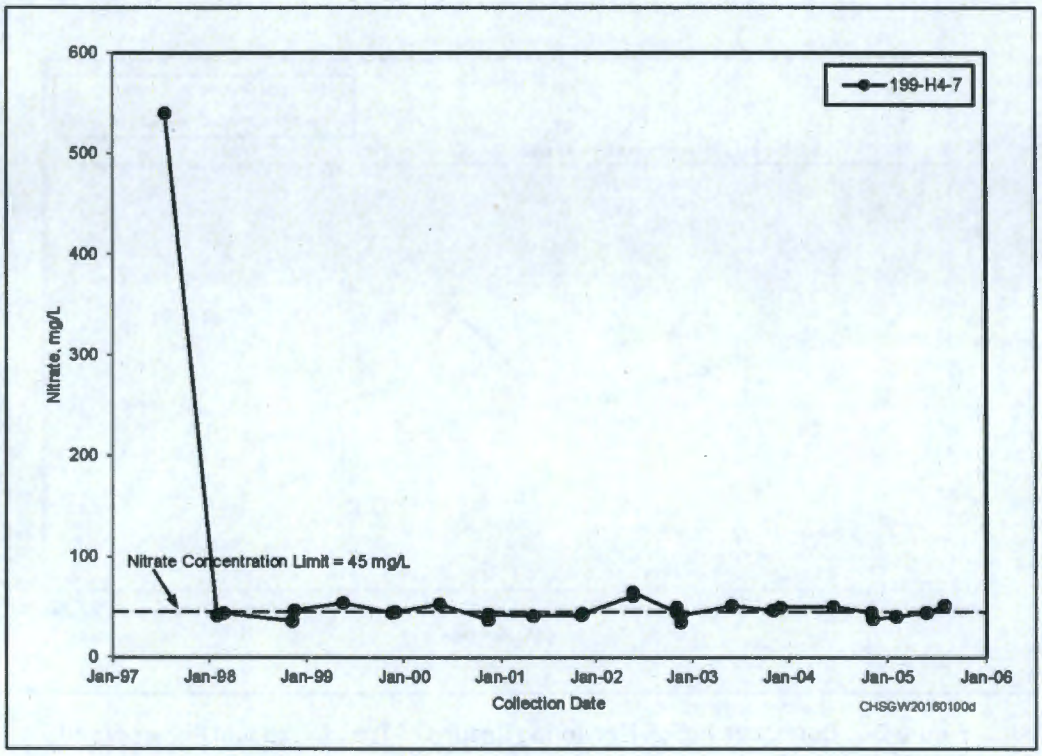

Figure D-9. Corrective Action Monitoring Results of Nitrate at Well 199-H4-7

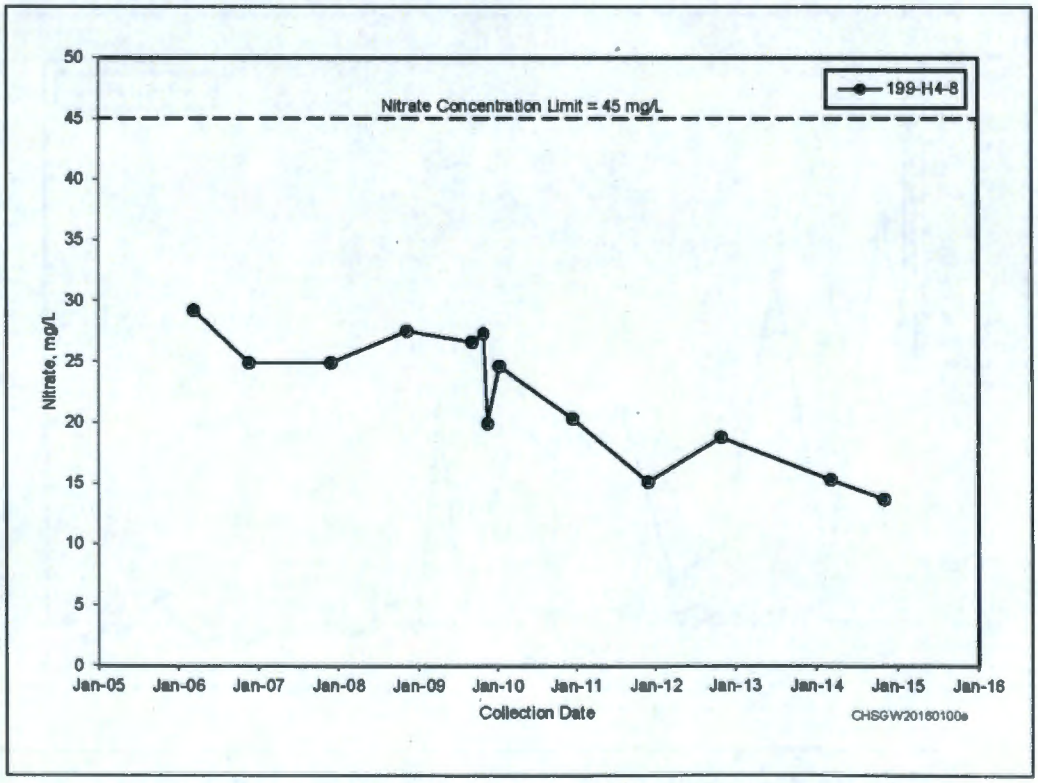

Figure D-10. Corrective Action Monitoring Results of Nitrate at Well 199-H4-8

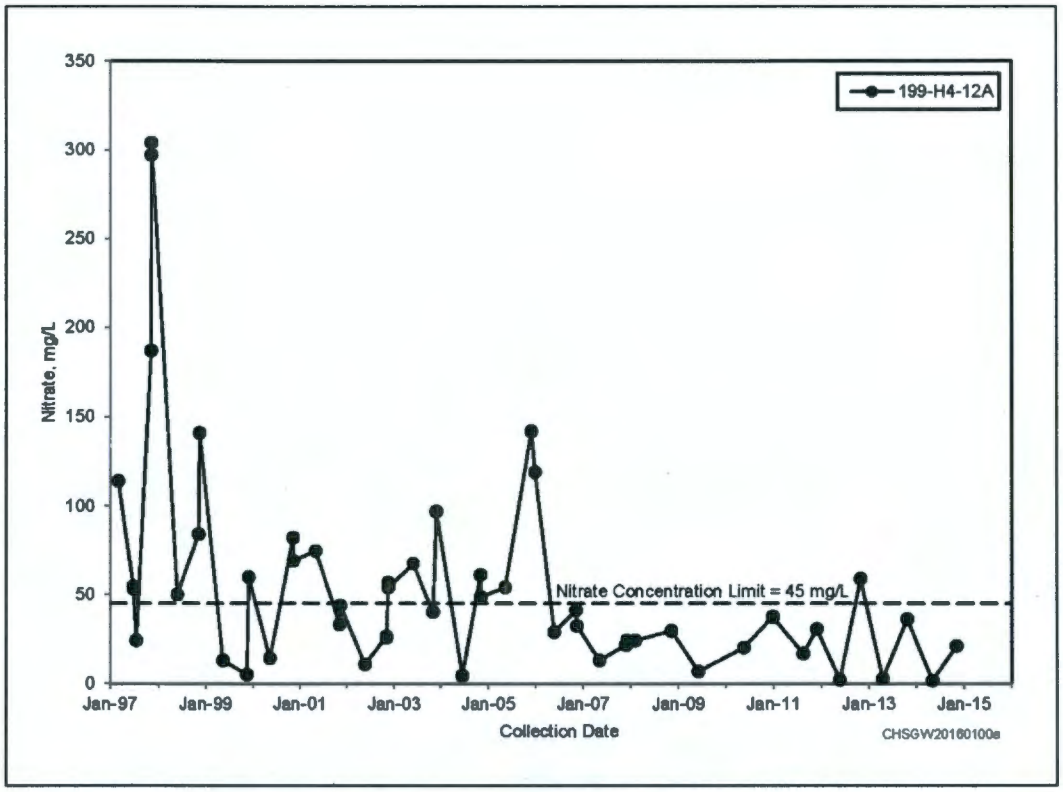

Figure D-11. Corrective Action Monitoring Results of Nitrate at Well 199-H4-12A

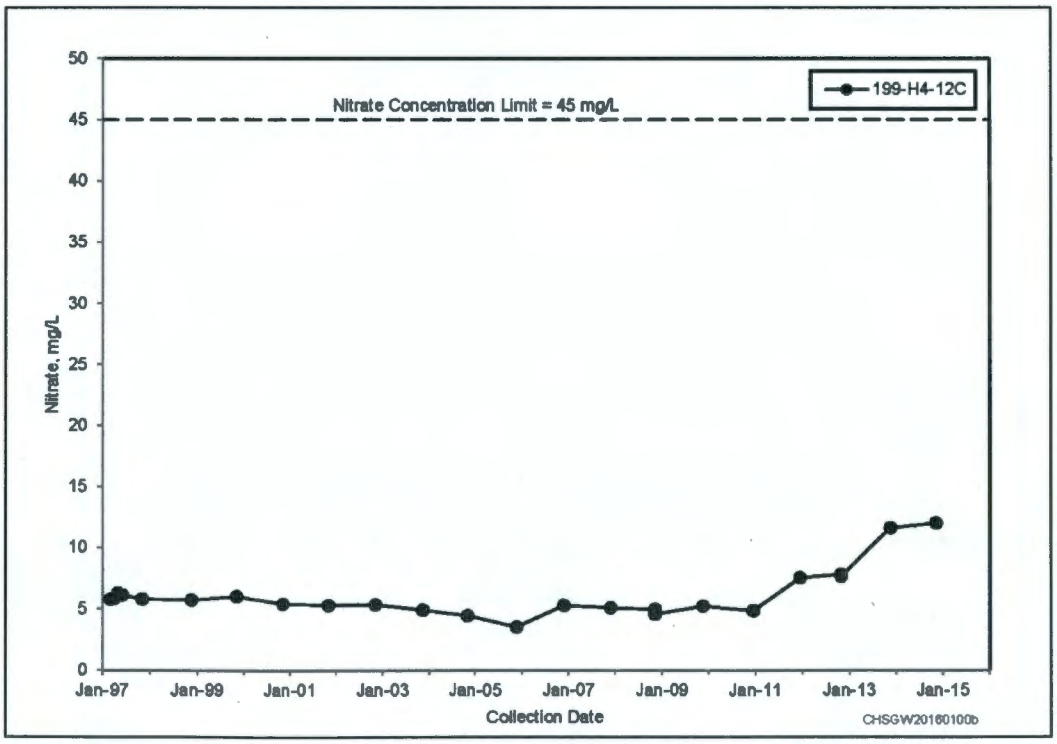

Figure D-12. Corrective Action Monitoring Results of Nitrate at Well 199-H4-12C

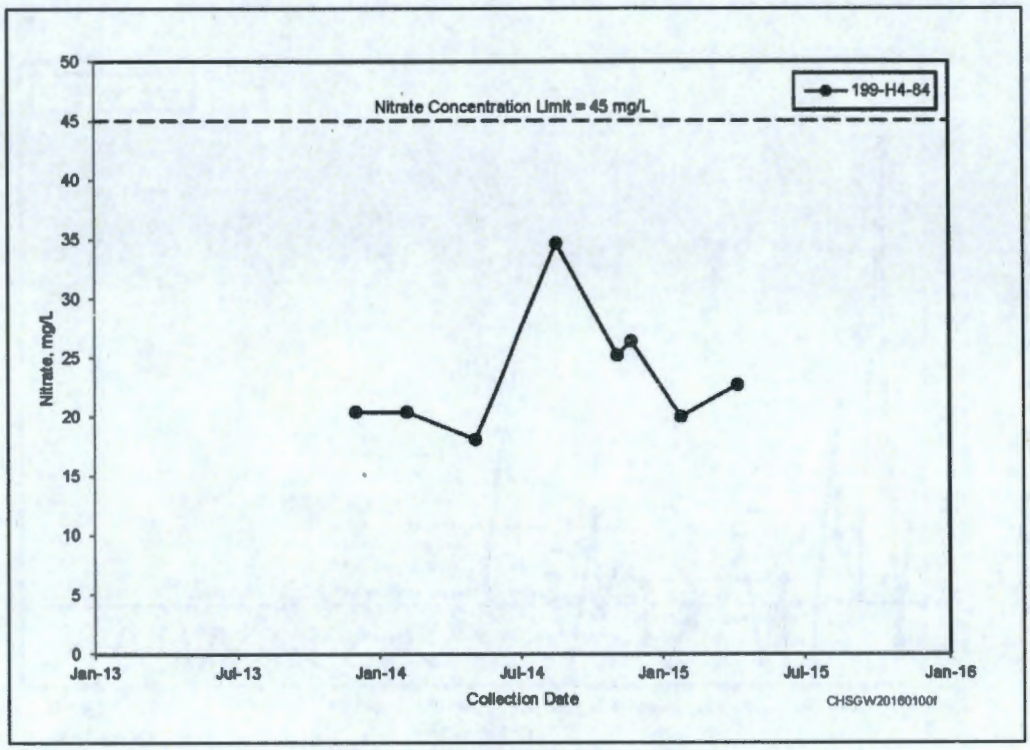

Figure D-13. Corrective Action Monitoring Results of Nitrate at Well 199-H4-84

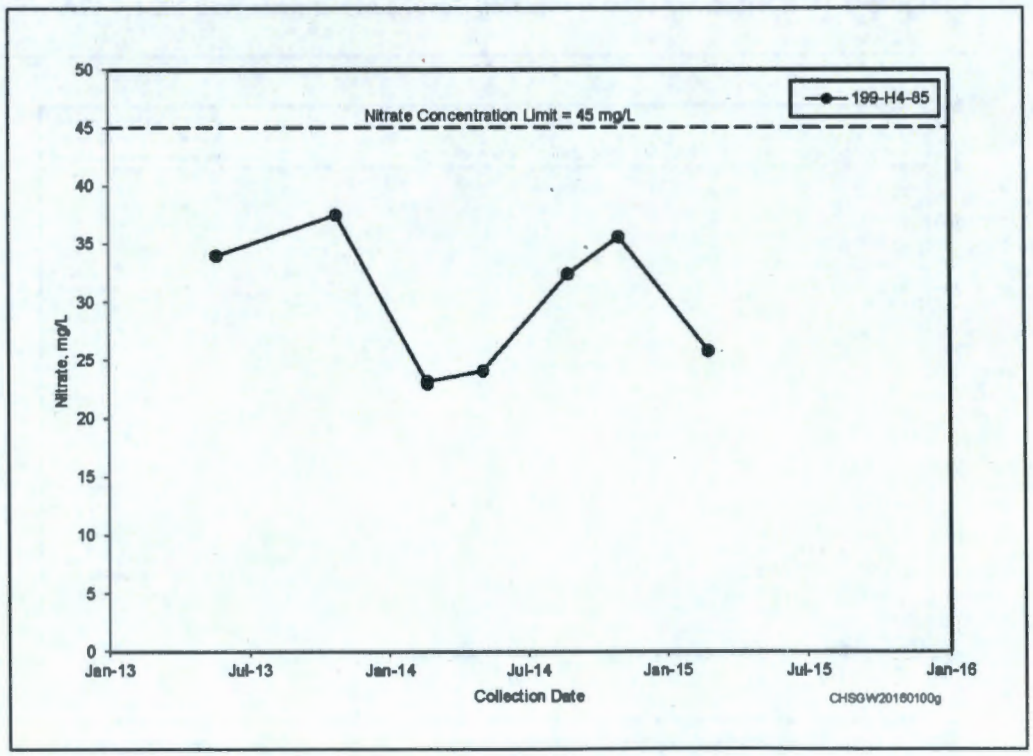

Figure D-14. Corrective Action Monitoring Results of Nitrate at Well 199-H4-85

D2 References

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epw.senate.gov/rcra.pdf.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: http://www.ecy.wa.gov/programs/nwp/permitting/hdwp/rev/8c/index.html.

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ENCLOSURE 3

Owner/Operator Certification

Consisting of 2 pages,
including this cover page

CERTIFICATION FOR CLASS 2 MODIFICATIONS TO REVISE GROUNDWATER MONITORING PLANS FOR THE 183-H SOLAR EVAPORATION BASINS AND 300 AREA PROCESS TRENCHES

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Doug S. Shoop

Doug S. Shoop, Manager
U.S. Department of Energy
Richland Operations Office

1/17/17
Date